CALIFORNIA FISH AND GAME

"CONSERVATION OF WILDLIFE THROUGH EDUCATION"

VOLUME 38 APRIL, 1952 NUMBER 2

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Please direct correspondence to:

Mr. Phil M. Roedel, Editor
California State Fisheries Laboratory
Terminal Island Station
San Pedro, California

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RESOLUTION OF THE FISH AND GAME COMMISSION HONORING LEE F. PAYNE

At its meeting on January 26, 1952, the Fish and Game Commission of the State of California unanimously adopted the following resolution:

WHEREAS, The Honorable Lee F. Payne has served as a member of the California Fish and Game Commission since September 19, 1939; as president of the commission from February 11, 1946, to January 9, 1948, and again during the year 1951; and

WHEREAS, During this period of more than 12 years Lee Payne has conscientiously and commendably served the public, the State of California, and the objectives of wildlife conservation; and

WHEREAS, During his tenure of office Commissioner Payne has merited the sincere respect and affection of all fish and game personnel for his many admirable qualities, prominent among which are his unerring keenness in reducing problems to their bare essentials, his firm decisiveness on controversial issues, and his unswerving loyalty to the fish and game organization and personnel; and

WHEREAS, This commission recognizes and appreciates that the conservation of our fish and game resources in California has been furthered through the efforts of the Honorable Lee F. Payne; now, therefore, be it

Resolved, That the thanks and appreciation of this commission and of the Department of Fish and Game are hereby expressed to Commissioner Lee F. Payne, upon the termination of his office as president of the commission, for his interest and effort during the past years, together with their hope that Commissioner Payne will continue to serve as an active member of this commission; and be it further

Resolved, That copies of this resolution shall be forwarded to the Governor of the State of California and to President Lee Payne of the Fish and Game Commission, and shall be published in the official journals of the Fish and Game Commission and the Department of Fish and Game.

NOTES ON THE SPAWNING OF THE HUMPBACK SUCKER, *XYRAUCHEN TEXANUS* (ABBOTT)[1]

By PHILIP A. DOUGLAS
Bureau of Fish Conservation
California Department of Fish and Game

INTRODUCTION

The humpback sucker, *Xyrauchen texanus* (Abbott) is one of the few native fishes remaining in the lower Colorado River drainage. In the spring of 1950 the writer made some observations on its spawning activities in Lake Havasu (an impoundment of the Colorado River), San Bernardino County, California. Other writers (see references) have published material on the humpback sucker, and some of these have recorded sexually mature fish, but none of them has included information on the spawning activities of the species. Thus, the writer believes that his presently described observations, incomplete as they are, are worthy of record in published form.

A general description of the lake, spawning locale, spawning observations, and collections in chronological order, are presented here.

GENERAL DESCRIPTION OF LAKE HAVASU

Water storage in this basin began in October, 1938, following completion of Parker Dam. The total capacity of Lake Havasu is 770,000 acre-feet, its maximum area is 20,000 surface acres, and its maximum depth is 82 feet. In 1950 the mean air and water temperatures were 74 degrees F. and 70 degrees F., respectively, while the air and water temperature ranges were 29-127 degrees F. and 42-85 degrees F., respectively. Mean rainfall in this Lower Sonoran Life Zone was 6.0 inches for this year. A brief chemical analysis made at Lake Havasu on October 10, 1950, by Metropolitan Water District hydrologists C. C. Elder and L. D. Martin is as follows: pH 8.3 at 23 degrees C.; ph-th 3 p.p.m.; M.O. 125 p.p.m.; hardness 311 p.p.m. $CaCO_3$; $CaCO_3$ 125 p.p.m.; $Ca(HCO_3)_2$ 186 p.p.m.; total alkalinity 618 p.p.m. $CaCO_3$; free CO_2 1.0 p.p.m.; electrical conductivity 994 reciprocal megohms. High winds are generally prevalent during the spring months. No stratification occurs because of the constant overturn in this shallow (average depth approximately 30 feet) lake. Current velocities are practically zero.

[1] Submitted for publication November, 1951. In view of the recent adoption of the common name "humpback sucker" in place of "razorback sucker" by the American Fisheries Society, the California Department of Fish and Game is taking a similar course.

SPAWNING LOCALE

The general area where the humpback sucker was observed in spawning activities is at the Needles Boat Landing, located in the northwest corner of Lake Havasu. Observations were made from the shore of a small bay south of the landing and its adjacent point.

FIGURE 1. Point south of Needles Boat Landing. *Photograph by R. D. Beland, January, 1951.*

The bottom of the bay is silt over sand intermixed with a smattering of boulders and some gravel spotted throughout the shallow areas. Numerous depressions over a foot in diameter were seen and appeared to be largemouth black bass (*Micropterus salmoides*) nests. Aquatic vegetation consists of small clumps of blue-green algae growing on the boulders and bottom, and bullrush (*Scirpus* sp.) patches along the marginal areas at the head of the bay. Tamarisk (*Tamarix gallica*) adds considerable shade to the littoral zone in the apex of the bay.

The bottom adjacent to the point to the south of this bay consists of a three-foot wide silt strip, located about 25 feet offshore, bordered by rubble both lakeward and shoreward. No aquatic vegetation was found in this area and the beach is open.

SPAWNING OBSERVATIONS

On March 2, 1950, Warden Leo Rossier and the writer noted spawning humpback suckers and carp (*Cyprinus carpio*) in the littoral area of the small bay and point south of Needles Boat Landing. Two suckers, both ripe males exuding milt, were seined. Their lengths were 21.2 and 21.3 inches and their weights 4.8 and 5.5 pounds, respectively.[2] They were in brilliant breeding coloration. The dorsal and lateral integument was black to a point about one inch below the lateral line, with a brilliant orange

[2] All length measurements are to fork of caudal fin.

coloration extending ventrad from this point. Limited time prevented further observations on this date.

On March 15th at 3.30 p.m. two groups of suckers were seen working their way along the marginal areas in the apex of the bay south of the landing approximately 15 feet from shore, in about 18 inches of water. In group one, six fish were noted revolving clockwise at a slow rate in four-foot diameter circles. Suddenly the caudal fins of all fish began to vibrate violently and one fish jumped clear of the water. It appeared that five of the fish, presumably males, were exerting pressure on one fish, presumably a female; three were crowding together on the female's right side and two on her left. The two most proximate males were pressing against the sides of the female with their heads just behind her hump. Ensuing violent motion raised bottom silt so that further observations were prohibited. Occasional water agitation was noted during this one and one-half minute period of activity and the location of the fish could easily be determined by the cloud of suspended matter raised from their violent motions. Following the spawning act the fish separated and moved away singly, two into deeper water and the other four parallel to the shore.

The second group consisted of three fish lying in a depressed pocket (possibly a largemouth black bass nest) about three feet from shore in 10 inches of water. Caudal fins of the two outer suckers, presumably males, began vibrating and a column of water about five inches high by seven inches in diameter was thrown into the air. Again bottom silt occluded the actual spawning act. After about one and three-quarters minutes of activity, the fish separated. A marine plankton net was towed through the immediate area, but no spawn was recovered.

Within one-half hour 48 suckers between 20 and 30 inches long were counted passing through this area. Carp were intermingling with the suckers and ranged in length between 10 and 15 inches. There was a slight wave action in the bay area, due to an easterly breeze.

On March 16th a strong east wind created wave action, preventing detailed observations of fish movements. However, a small school of suckers was located in the same area as of the previous afternoon, but no tight grouping was noted. A set was made with a standard sampling

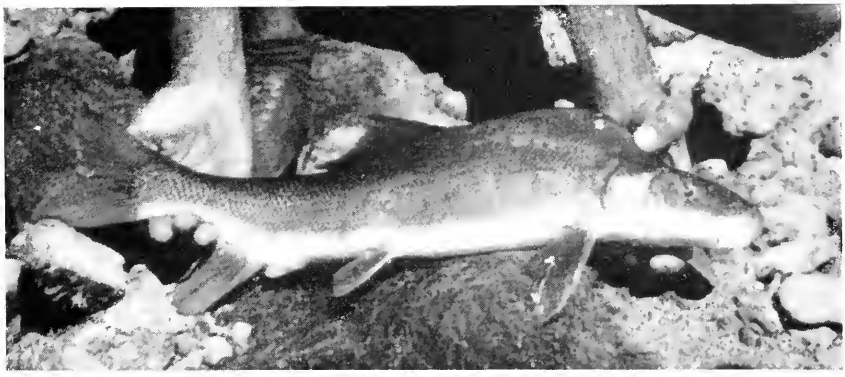

FIGURE 2. Humpback sucker, Xyrauchen texanus (Abbott). Specimen from Colorado River below Davis Dam. *Photograph by W. A. Evans, May 30, 1950.*

gill net at 10.15 a.m. and run at 12 m. Four suckers were captured, weighed and measured, and fin ray counts recorded. All were ripe males and extruded milt when removed from the net. They ranged from 4.8 to 5.6 pounds and 21.2 to 23.1 inches.[3]

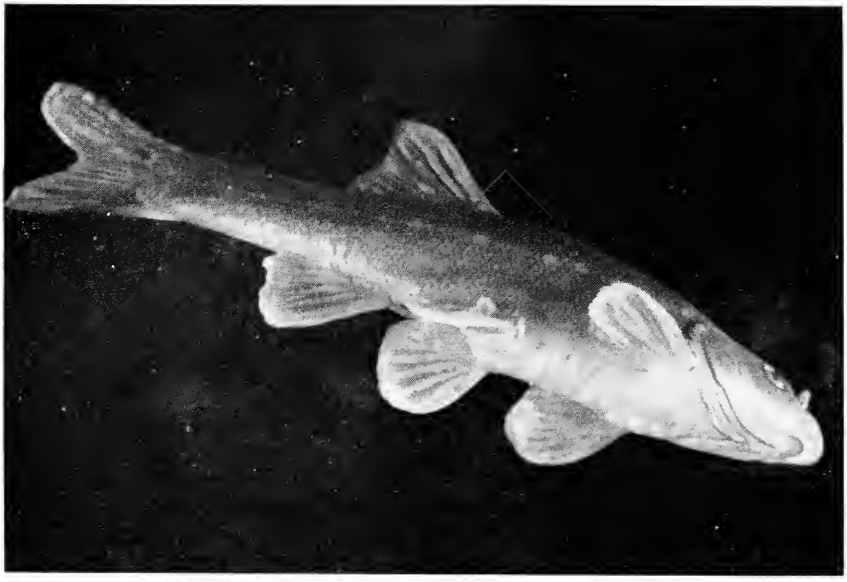

FIGURE 3. Four-inch humpbcak sucker from the Colorado River below Davis Dam. The nuchal hump is absent in this specimen. *Photograph by R. G. Hulquist, May, 1951.*

The surface was calm by noon but no spawning groups were seen. A few fish were jumping in the center of the bay. The gill net was run several times during the afternoon in an attempt to capture a gravid female sucker. Five suckers ranging from 4.3 to 5.5 pounds and 19.5 to 21.3 inches were caught, but all were ripe males.

At 3.05 p.m. some grouping of the suckers in the apex of the bay was noted, but no actual spawning appeared to be taking place. A slight surface ripple made observations somewhat difficult at this time. Two plankton tows were taken with the marine net. One complete tow consisted of a 40-foot drag each way. An area over the spawning grounds 15 feet by 40 feet was covered. All depths were sampled. No spawn was

[3] A few notes were taken on the physical appearance of one of these captured males, 5.3 pounds in weight and 21.5 inches in length. Pronounced breeding tubercles, approximately three-sixteenths inch in diameter and of about the same height, were noted on the lower nine rays of the caudal fin, and anteriad on approximately two and one-half inches of the lateral portions of the caudal peduncle; the seven rays of the anal fin were also bordered with tubercles. The pelvics were similarly covered with tubercles of somewhat smaller size, about one-eighth inch in diameter. An S-shaped pattern of tubercles was also noted over the frontal bone.

The mouth was typically sub-inferior. The dissection of the bone plate above the vertebrae, or the predorsal region between the occiput and dorsal fin, revealed a height range of 1.6 inches, taken just dorsad of the posterior edge of the opercle, to 1.2 inches at the base of the first dorsal ray. Two separations of the plate were found between the base of the dorsal spine and the apex of the nuchal hump, which divided the plate into thirds, presumably to permit lateral flexibility. Below the dorsal fin a fairly heavy plate, 1.0 inch high, extended over the entire length of the fish.

Fin ray counts for this specimen and the other three taken at the same time were constant at D-15, A-7, and C-18.

FIGURE 4. Larval humpback sucker taken near Needles Boat Landing, Lake Havasu. *Photograph by R. G. Hulquist, May, 1951.*

recovered, but one larval humpback sucker, 0.4 inch in total length, was captured (identification by Dr. Carl L. Hubbs).

On the morning of March 17th the bay area was watched from the previous location, but no suckers were in evidence. An overnight net set was run and only seven ripe carp and three bluegill (*Lepomis macrochirus*) were caught. By 10 a.m. it appeared that no suckers were moving into this bay area, so the observation station was moved to the first point south of the boat landing, where suckers had been collected on March 2d. The water surface was calm and 27 suckers were clearly visible milling about just offshore.

One group, consisting of two males and one female (presumably) between them, was noted moving in a counter-clockwise circle about three feet in diameter. The males appeared to be "herding" the female with their heads and humps, nudging the female in the genital region. After about 30 seconds of this circular movement all three lay on the bottom on their ventral surfaces. The males' caudal fins vibrated rapidly and appeared to be slapping the female in the genital region. At this time this group was in two feet of water approximately 25 feet from the shore, over silt bottom. Silt erupted with this activity and further observation was impaired. The silt cloud continued in suspension for three minutes before the fish were seen to separate and move away. This action was noted between 10.05 and 10.13 a.m.

A second group, consisting of three males and one female (presumably), was observed moving along the silt-bottomed strip between 10.15 and 10.17 a.m. The female escaped to deeper water and no spawning activity was noted. The female appeared lighter in color, being more brown than black on the dorsal side, but of the same size as the males. At 10.20 a.m. wave action from passing motor boats dispersed the groups and only single fish were seen.

By 10.45 a.m. only seven suckers were observed in the shallow area, though several silt "eruptions" were noted 50 feet offshore in 4.5 to 6 feet of water, and apparently some spawning activities were taking

place there. A silt cloud was observed about 50 yards south of the observation station and on moving to this point one female (presumably) and three males were seen resting on the bottom, after the silt had settled and the bubbles had cleared. In about four minutes all had dispersed and gone to deeper water.

At 11.09 a.m. six males chased one female (presumably) along the shoreline over the silt strip. Three males left and finally the entire group dispersed with no spawning activity having taken place.

At 11.10 a.m. another group of four males and one female (presumably) went into violent action following a short courtship. Visibility was again impaired and by 11.13 a.m. all the fish had dispersed.

Air and water temperatures recorded during this period are listed in Table 1.

TABLE 1

Temperature Record on Dates of Spawning Observations

Observation date in 1950	Time	Air temperature in degrees F.	Surface-shore water temperature in degrees F.
March 2	11.00 a.m.	63	62.5
March 15	3.30 p.m.	65	64
March 16	7.30 a.m.	67	58
March 16	12.00 m.	70	64
March 16	3.05 p.m.	71	65
March 17	9.30 a.m.	64	60

SUMMARY

In March, 1950, the writer discovered spawning humpback suckers in the littoral areas of Lake Havasu, San Bernardino County, California. Their activities were observed and sample gill net catches made of nine ripe males. No females were captured. Size ranges were recorded. One larval sucker was recovered in a plankton net tow. Temperature and time data were taken.

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RESULTS OF THE EXAMINATION OF FOUR SMALL YELLOWFIN TUNA, *NEOTHUNNUS MACROPTERUS*[1]

By E. C. GREENHOOD
Bureau of Marine Fisheries
California Department of Fish and Game

In the past few years we have had the opportunity to examine four small yellowfin tuna ranging from 216 to 302 mm. in body length. Three of these specimens, 216, 219, and 219 mm. were collected in the Hawaiian area on August 16, 1948 (lat. 23° 18′ N, long. 163° 00′ W.). These fish were caught in two and one-half inch mesh drift gill nets during an exploratory tuna trip made by the department's research vessel N. B. SCOFIELD. The fourth, 302 mm. in body length, came from Costa Rican waters. It was caught by the live bait boat SONYA May 15, 1950, in proximity to a floating log, which, according to the skipper, sheltered an abundance of small yellowfin.

[1] Submitted for publication July, 1951.

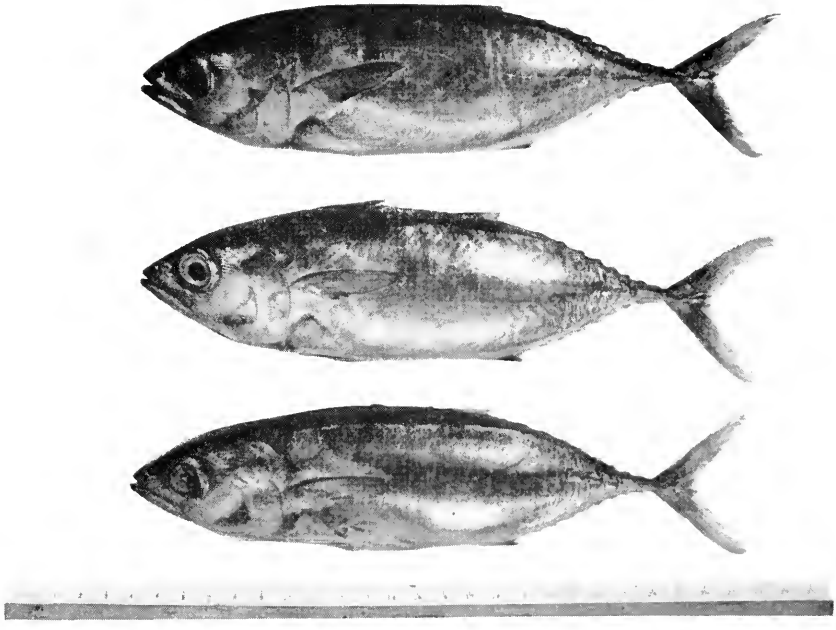

FIGURE 1. Small yellowfin tuna (*Neothunnus macropterus*) from the Hawaiian area. *Photograph by Al Johns for Vernon M. Haden, San Pedro.*

TABLE 1

YELLOWFIN TUNA

The Range in the Various Body Proportions

Body proportion	Costa Rica, small	Costa Rica, large	Hawaiian, small	Hawaiian, large	All yellowfin, large
Range in body length—mm.	302	619–640	216–219	535–573	506–1200
Body length / Head length	3.47	3.35–3.54	3.60–3.65	3.35–3.52	3.31–4.00
Body length / 1st dorsal insertion	2.99	3.02–3.20	3.09–3.20	3.01–3.19	2.96–3.55
Body length / 2d dorsal insertion	1.74*	1.76–1.85	1.75–1.80	1.77–1.83	1.76–1.98
Body length / Anal insertion	1.57	1.58–1.65	1.62–1.63	1.61–1.67	1.57–1.75
Body length / Ventral insertion	2.99	2.99–3.17	3.13–3.22	3.07–3.17	2.99–3.56
Body length / Body depth	3.87	3.50–3.75	3.78–3.86	3.56–4.09	3.50–4.09
Body length / Body width	6.71*	5.20–5.57	7.30–7.82*	5.56–5.99	5.20–6.20
Body length / Dorsal-ventral distance	4.03	3.64–3.88	4.02–4.17	3.81–4.21	3.64–4.35
Body length / Dorsal-anal distance	2.50	2.46–2.58	2.47–2.54	2.52–2.61	2.45–2.69
Body length / Length 1st dorsal base	3.87*	3.95–4.21	3.91–4.00	3.90–4.16	3.88–4.30
Body length / Pectoral length	4.14	3.33–3.93	4.92–5.40*	3.11–3.56	3.11–4.21
Body length / Height 1st dorsal	8.88	8.21–9.65	7.96–10.29	7.54–9.43	7.54–10.61
Body length / Height 2d dorsal	12.58*	----------	14.13–14.40*	7.83–8.95	5.39–10.17
Body length / Height of anal	15.10*	9.43	14.40–15.10*	7.72–9.76	4.43–11.76
Body length / Length 2d dorsal base	9.44	9.41–11.68	9.13–10.29	8.66–11.63	8.57–12.41

TABLE 1—Continued

YELLOWFIN TUNA

The Range in the Various Body Proportions

Body proportion	Costa Rica, small	Costa Rica, large	Hawaiian, small	Hawaiian, large	All yellowfin, large
Body length / Length of anal base	12.58	11.25–12.80	9.13–9.39*	11.67–12.93	9.89–14.68
Body length / Spread of caudal	4.44*	3.55–3.97	3.71–4.17	3.27–3.85	3.27–3.97
Head length / Diameter of iris	5.12*	6.46–6.89	4.62–5.00*	5.61–6.27	5.57–8.56
Head length / Maxillary length	2.56	2.54–2.62	2.40–2.50	2.50–2.56	2.46–2.67
Body length / Ventral fins to anterior margin of vent	3.21	----	----	----	----

* Falls outside of range previously determined for all larger specimens.

All specimens were frozen upon capture and were subsequently thawed prior to measuring.[2] The freezing and subsequent storage resulted in a slight shrinkage which, in all probability, caused some distortions in body proportions. Mr. H. C. Godsil, Department of Fish and Game, identified all specimens from external and internal characters. Little information is available on small sizes of yellowfin tuna. There are changes that these fish undergo in developing from the juvenile to the adult stages and in order to show some of these external changes, proportions have been shown as well as the original measurements. Likewise, a brief description of the viscera is given. Table 1 shows, for comparison, the proportions based upon the small specimens and those based upon samples of larger fish from Costa Rica, Hawaii, and the Pacific in general; there being 12 larger fish from each of the two specified areas, and 101 fish from the entire Pacific. In each case the range in body length is shown on the first line of Table 1. In Table 3 the original measurements are recorded. All meristic counts taken were within the range of previously described specimens.

DISCUSSION OF PROPORTIONS

From Table 1, it is obvious that the ratios of body length to body width, height of second dorsal and height of anal differ markedly in the smaller tuna. The small fish are relatively more compressed laterally. Thus, in the small Hawaiian specimens the body width goes into body length 7.30 to 7.82 times, whereas in the larger fish from the composite Pacific sample the ratio varies from 5.20 to 6.20. The Costa Rican specimen was slightly less compressed laterally than the smaller Hawaiian individuals, the ratio

[2] Measurements were made according to the procedure described by Godsil and Byers (1944) and Godsil and Holmberg (1950).

being 6.71. In the case of the ratio of height of second dorsal to body length, a similar relationship exists. The small yellowfin tuna have a relatively lower fin. Likewise, the height of the anal fin is relatively less in smaller fish.

In a comparison of diameter of iris with head length, it appears that the smaller the specimen the larger is the eye in relation to head length. Here, as in the other measurements cited, the proportions are a function of size and change as growth and development progress.

In the small Costa Rican specimen there is the suggestion that the distance to the insertion of the second dorsal fin and the length of first dorsal base is longer. The spread of the caudal fin is relatively smaller. In the small Hawaiian specimens it appears that the length of the pectoral fin is proportionately shorter, while the length of the anal base is relatively longer. In all probability these differences in proportions, in fish of varying length, will be accentuated as additional measurements on smaller fish become available.

VISCERA

In ventral view, the viscera of the small Costa Rican specimen conformed to the typical yellowfin pattern. (See Table 2 for original measurements.) The exceptions were minor and were within the range of variations encountered in previous work. The center lobe of the liver did not show in the routine sketch. Either this lobe was extremely small, or it had been inadvertently removed in the preparation. The spleen was relatively large and lay with the head on the right side, but median to the fold of the intestine instead of lateral to this. As a consequence, the concave indentation which delimits the head of the spleen faced laterally instead of medially as in the majority of specimens. The fold of the intestine was relatively short. The air bladder, though extremely small, was typical in shape and position. In view of the degree of variation encountered in numerous dissections, these minor differences are not considered significant.

TABLE 2

YELLOWFIN TUNA

Original Internal Measurement in Millimeters

	Costa Rican	Hawaiian No. 1	Hawaiian No. 2	Hawaiian No. 3
Total length of abdominal cavity	109	78	78.5	76.5
Liver		Not obtained		
Caecal Mass	52*		Not determined	
Stomach	64	66.5	59	63.5
Intestine				
Anterior loop	54	31.5	38	34.5
Posterior loop	80.5	66	62	65
Air bladder	Not determined	22.5*	20*	16.5

* Approximate value.

The viscera of the Hawaiian specimens were typical in general arrangement and appearance. However, the physical condition of the viscera was poor, and no detailed sketches were made.

TABLE 3

YELLOWFIN TUNA

Original Measurements in Millimeters

	Costa Rican	Hawaiian No. 1	Hawaiian No. 2	Hawaiian No. 3
Body length	302	216	219	219
Head length	87	60	60	60.5
1st dorsal	101	70	68.5	70
2d dorsal	174	122	122	125
Anal	192	133	134.5	135
Ventral	101	67.5	68	70
Body depth	78	56	58	58
Body width	45	29.5	28	30
Dorsal ventral distance	75	52	52.5	54.5
Dorsal anal distance	121	85	88.5	88
Length 1st dorsal base	78	51	55.5	56
Pectoral length	73	40	44.5	43
Height 1st dorsal	34	21	27.5	23
Height 2d dorsal	24	15	15.5	15.5
Height of anal	20	15	14.5	14.5
Length 2d dorsal base	32*	21	24	24
Length anal base	24	23*	24*	24*
Spread of caudal	approx. 68	51	52.5	59
Diameter of iris	17	13	12	12.5
Maxillary length	34	24	25	25
Ventral to ventral	91			

* Includes first finlet.

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CRUSTACEA COLLECTED DURING THE 1950 BOTTOM-FISH INVESTIGATIONS OF THE M. V. *N. B. SCOFIELD* [1]

By DELBERT G. GOODWIN
California Academy of Sciences
San Francisco

The California Department of Fish and Game research vessel N. B. SCOFIELD conducted extensive research on the bathymetric and zoogeographic association of the fauna along the coast of California during the year 1950. Primarily, the survey was made to investigate and gather additional data concerning the life history of the bottom fishes offshore.

During the course of this investigation, as well as in the past, the biologists aboard the N. B. SCOFIELD [2] were confronted with the pressure of more current problems and an allotted schedule of time for research. Some of the by-products of their investigations were set aside by necessity rather than by choice. For this reason, many of the invertebrates which did not apparently exhibit any direct relationship to the bottom-fish investigation could not be given critical attention in proportion to their ecological significance.

During the course of the investigation, the greater quantity of specimens caught was bottom fishes taken on the continental shelf. Many other abyssal forms of marine life, which may or may not be of some commercial significance, were also collected. Many of these specimens, although of little or no market desideration, are scientifically valuable and have been preserved, labeled, and presented to the California Academy of Sciences for further study.

In addition to the bottom fishes and marine invertebrates incidental in the catches of the N. B. SCOFIELD, it was apparent that prawns, shrimp, and crabs were taken with regularity and consisteney in certain areas along the ocean floor, indicating their abundance in the California marine decapod fauna. Although the beam trawl used by the N. B. SCOFIELD was a suitable net for the bottom-fish investigation, it was neither designed nor intended to function as a shrimp net. In view of this feature, the prawns and shrimp taken incidentally with the bottom fishes in the net merited further research. The conviction that the California coastal waters were capable of providing a potential source of supply for the State's minor shrimp fishery was strengthened as the investigation progressed. It became apparent that prawns and shrimp existed in large enough size and abundance to justify a limited offshore fishery.

In the fishing industry, the depth at which the prawns, shrimp, and crabs occur may easily be a limiting factor in determining the success or failure of any potential offshore operation. A majority of the prawns

[1] Submitted for publication May, 1951.
[2] The author wishes to acknowledge the efforts of the crew aboard the N. B. SCOFIELD and the generous contributions of biologists Wm. Ellis Ripley, Keith W. Cox, and J. B. Phillips.

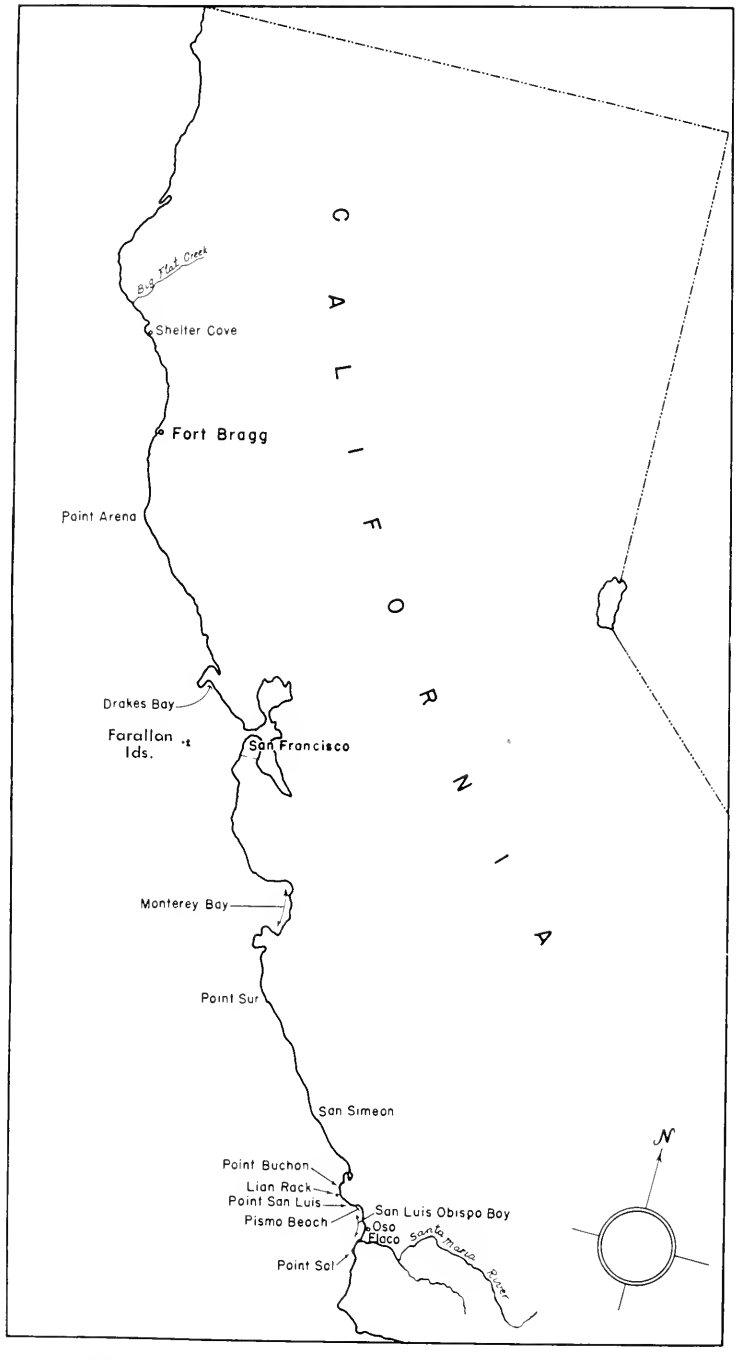

FIGURE 1. Northern California, showing the area explored by the *N. B. Scofield*

and shrimp of commercial desideration which could support a limited amount of fishing were taken at a depth varying from 20 fathoms to 220 fathoms, depending upon the species, the season of the year, and the area being surveyed. In general, the biologists of the N. B. SCOFIELD found sizable "beds" of prawns and shrimp around the 100 fathom curve; however, fishing was successful in shallower as well as in slightly deeper waters.

There are indications that limitations in the local distribution of the prawn, shrimp, and crab populations are closely correlated with the character of the ocean bottom. In areas surveyed during 1950, shrimp showed a marked preference for a bottom habitat composed of fine, more or less greenish mud, or greenish mud and sand. The large prawns were found predominantly in or near rocky areas, or in areas with a combination of rocks and muddy sand.

Depth and temperature are apparently of minor significance in governing the local distribution of the prawns, shrimp and crabs; however, salinity is of major importance in areas of pollution and of dilution by fresh water.

The biological barriers which restrict the distribution of the California shellfish are not completely understood at present. Salinity, substratum, temperature, geographic and bathymetric influences unquestionably are controlling factors of offshore species. The extent of the prawn and shrimp "beds" and the location of new ones are of primary interest to the California Department of Fish and Game. As the investigation progresses, additional and more comprehensive information concerning the factors influencing the concentration and distribution of prawns, shrimp, and crabs along the coast of California will be obtained.

The following report was compiled with the realization that much has been left unanswered. The identification and ranges of the different species taken during the 1950 bottom-fish investigation are included, with the hope that they may serve as an aid to future work. All data included are based upon the specimens submitted to the invertebrate zoology laboratory at the California Academy of Sciences and do not necessarily indicate the complete bathymetric or geographic distribution, the total number of different species occurring along the California coast or the total quantity of any one species taken during the field work of the N. B. SCOFIELD.

FAMILY PENEIDAE

Genus *Gennadas* Bate

Gennadas borealis Rathbun

Type Locality: Off Copper Island, Kamchatka, 1567 fathoms, Station 3783, *Albatross*.
General Range: "Taken in Bering Sea, north of Rat Islands, Aleutians, to off South Coronado Island, Baja California, 266 to 2182 fathoms" (Schmitt).
Local Distribution: Off Southeast Farallon Island (Sta. 50 B.88), 700-820 fathoms, 1 specimen.
Remarks: Positive identification of this specimen was uncertain due to poor state of preservation.

FAMILY PANDALIDAE
Genus *Pandalus* Leach
***Pandalus jordani* Rathbun**

Type Locality: Off Santa Cruz, California, 155 fathoms ("Albatross" Station 2949).

General Range: "From Unalaska to off San Diego, California, 25 to 199 fathoms" (Schmitt).

Local Distribution: Off Big Flat, between Stillman (Shipman) and Big Flat Creek, Humboldt County, to San Luis Obispo Bay, California; 60 fathoms to 180 fathoms.

Collecting Stations: Off Big Flat, between Stillman (Shipman) and Big Flat Creek, Humboldt County (Sta. 50 B.7), 60-64 fathoms, 11 specimens; off Fort Bragg, Mendocino County (Sta. 50 B.20), 100-125 fathoms, 1 specimen; off San Luis Obispo Light (Sta. 50 B.48), 80 fathoms, 4 specimens; off Santa Maria River, near Point Sal (Sta. 50 B.54), 75 fathoms, 36 specimens; and off Pismo Beach, San Luis Obispo Bay (Stations 50 B.55, 56, 58, 61 to 66, 69 to 72, and 75 to 82), 68 fathoms to 180 fathoms.

Remarks: *Pandalus jordani* was taken at 17 stations from 50 B.7 to B.82 and only seven of these stations failed to produce bottom fish.

Bottom samples dredged from Stations 50 B.73 to B.78 revealed the bottom to be green mud with some fine sand. *Pandalus jordani* was found to associate with *P. platyceros*, *P. danae*, *Spirontocaris lamellicornis*, *S. bispinosa*, *Crago communis*, *C. resima*, and *C. spinosissima* at other stations.

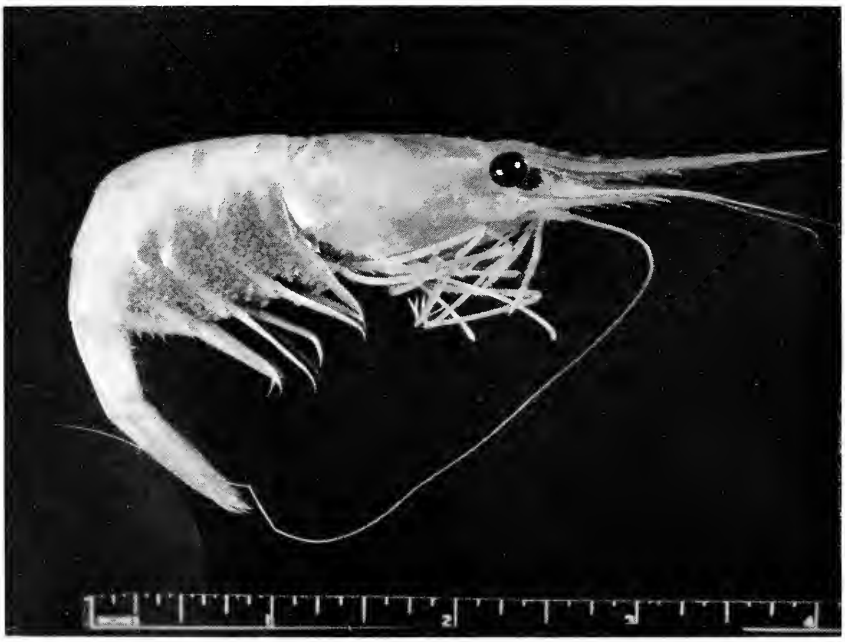

FIGURE 2. *Pandalus jordani*, lateral view. Off Pismo Beach, California. 72-82 fathoms. *Photograph by Frank L. Rogers, December, 1950.*

Pandalus platyceros Brandt

Type Locality: Unalaska.

General Range: "Unalaska to off San Diego, California, 25 fathoms to 226 fathoms." (Schmitt.)

Local Distribution: San Luis Obispo Bay, 56 fathoms to 220 fathoms.

Collecting Stations: Off Santa Maria River, near Point Sal, San Luis Obispo Bay (Sta. 50 B.53 and 50 B.54), 56-75 fathoms, 12 specimens; west of Pismo Beach, San Luis Obispo Bay (Sta. 50 B.56 to 50 B.58), 100-220 fathoms, 9 specimens; San Luis Obispo Bay (Stations 50 B.61 to 50 B.78), 68-110 fathoms.

Remarks: This "prawn" was found to associate with *Pandalus jordani, Spirontocaris lamellicornis, S. bispinosa, Crago communis, C. resima, and C. spinosissima* at various stations along the coast of California.

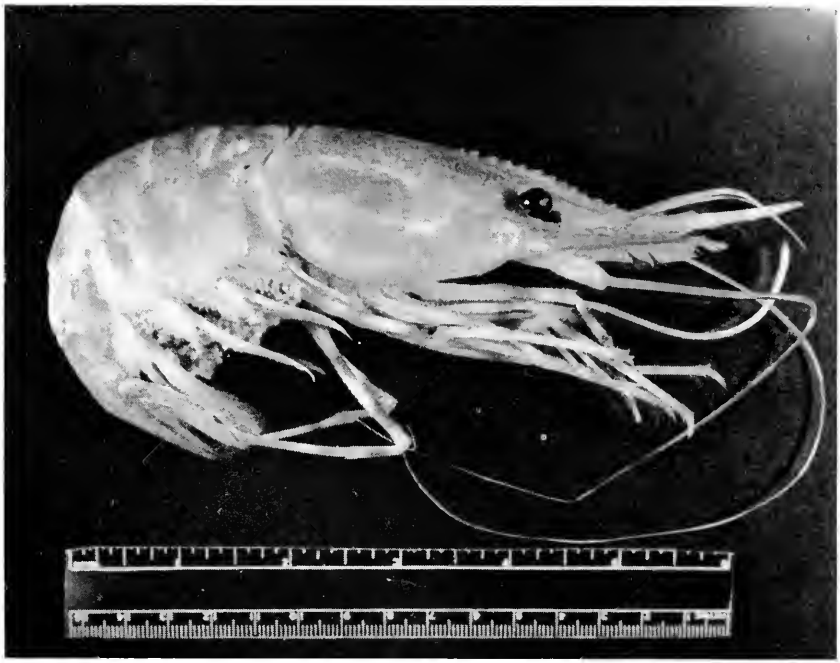

FIGURE 3. *Pandalus platyceros,* female with eggs; lateral view. Off Santa Maria River, California, 56-75 fathoms. *Photograph by Frank L. Rogers, December, 1950.*

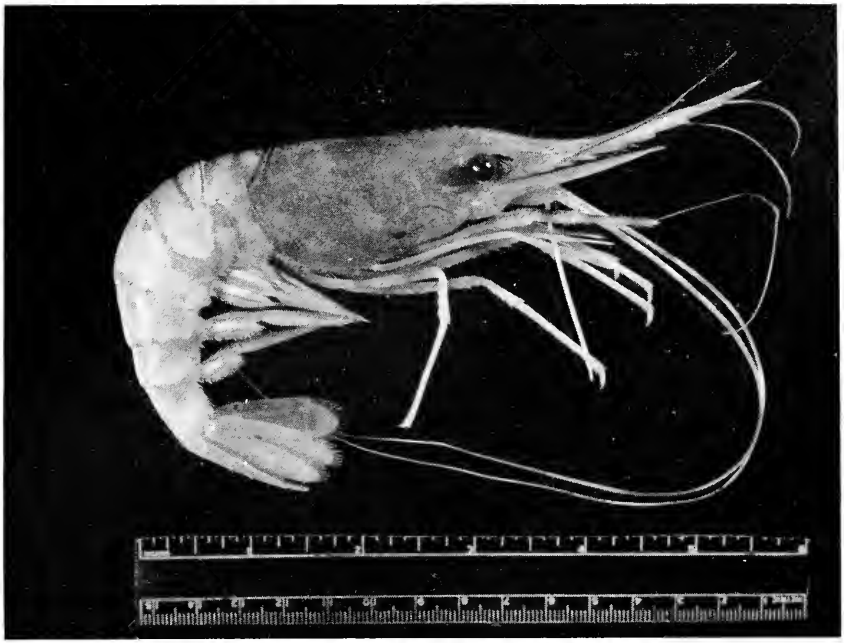

FIGURE 4. *Pandalus platyceros*, male; lateral view. West of Pismo Beach, California, 100-125 fathoms. *Photograph by Frank L. Rogers, December, 1950.*

Pandalus danae Stimpson

Type Locality: Puget Sound.

General Range: "From Sitka, Alaska, to San Francisco, California, 10 to 101 fathoms" (Schmitt).

Local Distribution: North of Drakes Bay to Pismo Beach, San Luis Obispo Bay, 19 to 82 fathoms.

Collecting Station: North of Drakes Bay (Sta. 50 B.85), 22 to 19 fathoms, 2 specimens; Drakes Bay (Sta. 50 B.84), 20-23 fathoms, 4 specimens; west of Pismo Beach (Sta. 50 B.80), 82 fathoms, 1 specimen.

Remarks: As far as it is known, no reports have recorded *Pandalus danae* south of San Francisco, California. This prawn was taken in quantity off Pismo Beach, San Luis Obispo Bay by the N. B. Scofield which extends the geographic range a considerable distance south.

P. danae was also taken with *P. jordani*, *Spirontocaris lamellicornis*, *S. cristata*, *Crago nigromaculata*, *C. communis*, and *C. spinosissima* at other stations along the coast of California.

FIGURE 5. *Pandalus danae* (coon-stripe prawn), female with eggs; lateral view. North of Drakes Bay, California, 19-22 fathoms. *Photograph by Frank L. Rogers, December, 1950.*

FAMILY HIPPOLYTIDAE
Genus *Spirontocaris* Bate
Spirontocaris lamellicornis (Dana)

Type Locality: "Dungeness, Straits of Fuca" (Schmitt).
General Range: "This species occurs sparingly from Unalaska to Point Arena, California, 9 to 77 fathoms" (Rathbun).
Local Distribution: From Drakes Bay to Pismo Beach, San Luis Obispo Bay, 20 to 110 fathoms.
Collecting Stations: Drakes Bay (Sta. 50 B.84), 20-23 fathoms, 1 specimen; Drakes Bay (Sta. 50 B.86), 20-21 fathoms; off Pismo Beach, San Luis Obispo Bay (Sta. 50 B.72-82), 80-110 fathoms, 13 specimens.
Remarks: The occurrence of *Spirontocaris lamellicornis* as far south as Pismo Beach, California extends the range beyond its recorded southern range of Point Arena.

Previous to this time, the recorded maximum depth at which this species has been taken was 77 fathoms. The N. B. Scofield has taken this shrimp consistently in San Luis Obispo Bay in depths from 80 fathoms to 110 fathoms, which establishes a new bathymetric distribution for this species.

This shrimp was found to associate with other species of prawns and shrimp such as *Pandalus jordani, P. platyceros, P. danae, Spirontocaris cristata, Crago nigromaculata, C. communis,* and *C. spinosissima* at other stations along the coast of California.

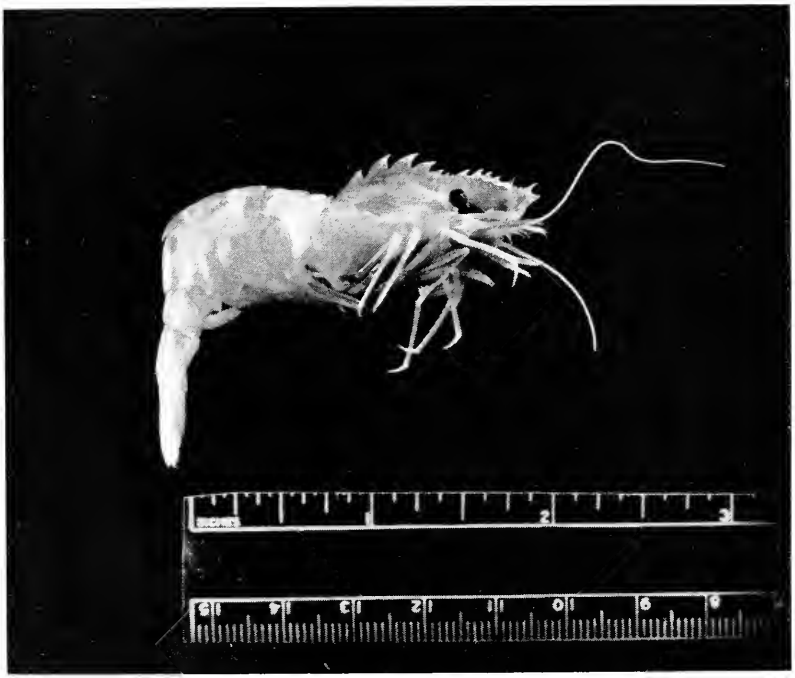

FIGURE 6. *Spirontocaris lamellicornis* (broken-back shrimp), lateral view. Drakes Bay, California, 20-23 fathoms. *Photograph by Frank L. Rogers, December, 1950.*

Spirontocaris bispinosa Holmes

Type Locality: Puget Sound.
General Range: "From Yes Bay, Alaska, to off San Diego, California, 13 to 211 fathoms" (Schmitt).
Local Distribution: From Fort Bragg, Mendocino County, to Santa Maria River, San Luis Obispo Bay, 75 to 125 fathoms.
Collecting Station: From Fort Bragg (Sta. 50 B.20), 100-125 fathoms, 1 specimen; between Santa Maria River and Point Sal (Sta. 50 B.54), 75 fathoms, 3 specimens.

Remarks: At various stations along the California coast this species was found to occur in association with *Pandalus jordani, P. platyceros, Crago communis,* and *C. nigromaculata.*

Spirontocaris cristata (Stimpson)

Type Locality: San Francisco, California.
General Range: "Sitka, Alaska, to San Diego, California" (Rathbun).
Local Distribution: Drakes Bay, California, 19 to 22 fathoms.
Collecting Station: Drakes Bay (Sta. 50 B.85), 22-19 fathoms, 5 specimens; southwest of Drakes Bay (Sta. 50 B.86), 20-21 fathoms, 6 specimens.
Remarks: This shrimp was collected with *Pandalus danae, Spirontocaris lamellicornis,* and *Crago nigromaculata* at different stations along the coast of California.

FAMILY CRAGONIDAE
Genus *Crago* Lamarck

Crago nigromaculata (Lackington)

Type Locality: San Diego, California, 6 fathoms.
General Range: "From Northern Californa to Baja, California, 3 to 33 fathoms" (Rathbun).
Local Distribution: Drakes Bay, California, 20-23 fathoms.
Collecting Stations: Drakes Bay (Sta. 50 B.84), 20-23 fathoms, 4 specimens; southwest of Drakes Bay (Sta. 50 B.86), 20-21 fathoms, 6 specimens.
Remarks: *Crago nigromaculata* was found to associate with other shrimp and prawns along our coast. It was taken at various stations with *Pandalus danae,* with *Spirontocaris lamellicornis,* and with *S. cristata.*

Crago communis (Rathbun)

Type Locality: Off Pribilof Islands, Bering Sea, 51 fathoms ("Albatross" Sta. 3441).
General Range: "Bering Sea to San Diego, California, 9 to 309 fathoms" (Schmitt).
Local Distribution: Pismo Beach, California, to Santa Maria River, 75 to 110 fathoms.
Collecting Station: Northwest of Pismo Beach (Sta. 50 B.72-82), 80-110 fathoms, 5 specimens; south of San Luis Obispo Light (Sta. 50 B.48) 80 fathoms, 1 specimen; between Santa Maria River and Point Sal (Sta. 50 B.54), 75 fathoms, 4 specimens.
Remarks: The association of *Crago communis* with other species of shrimp and prawns at different stations and depths is widely diversified. It occurred with *Pandalus jordani, P. platyceros, P. danae, Spirontocaris lamellicornis, S. bispinosa, Crago resima,* and *C. spinosissima.*

Crago resima (Rathbun)

Type Locality: Off San Diego, California, 124 fathoms ("Albatross" station 2935).
General Range: "From off San Francisco, California, to San Domingo Point, Baja, California, 15 to 266 fathoms" (Schmitt).
Local Distribution: Off Santa Maria River, near Point Sal, 75 fathoms.
Collecting Station: Between Santa Maria River and Point Sal (Sta. 50 B.54), 75 fathoms, 2 specimens.
Remarks: *Crago resima* was found to tolerate various other shrimp and prawns in its habitat, particularly *Pandalus jordani, P. platyceros, Spirontocaris bispinosa,* and *Crago communis.*

Crago spinosissima (Rathbun)

Type Locality: Off Point Arena, California, 51 fathoms ("Albatross" station 3351).
General Range: "Off Oregon and California, 15 to 96 fathoms." "So far as known Point Fermin is the southern limit of this species" (Schmitt).
Local Distribution: Off Pismo Beach, San Luis Obispo Bay, California, 80 to 110 fathoms.
Collecting Stations: Northwest and southwest of Pismo Beach, San Luis Obispo Bay (Sta. 50 B.72-82), 80-110 fathoms, 1 specimen.
Remarks: The recorded maximum range in depth at which *C. spinosissima* occurs has been 96 fathoms. Specimens taken in San Luis Obispo Bay in 80-110 fathoms extends the maximum depth 14 fathoms beyond the reported range.

This shrimp was found to occur frequently with *Pandalus jordani, P. platyceros, P. danae, Spirontocaris lamellicornis,* and *Crago communis* at other stations.

TABLE 1

"N. B. Scofield" Stations Along the Coast of California in 1950 Recording Only Shrimp and Prawn Catches
All Specimens Were Taken in a Beam Trawl With 3½-Inch Mesh Body and 1-Inch Mesh Bag

Station No. 50B.	Date 1950	General locality	Course of ship	Depth in fathoms	Duration of haul	Prawns and shrimp taken in each haul
20	10/12	Off Fort Bragg	S. ¾ E.	100–125	1318–1354	Pandalus jordani, Spirontocaris bispinosa
48	10/21	50°T. to San Luis Obispo Bay Light	S. ½ W.	80	1931–2013	Pandalus jordani, Crago communis
53	10/22	Off Santa Maria River, near Pt. Sal, San Luis Obispo Bay	NE. by N.	56–75	1401–1443	Pandalus platyceros
54	10/22	Off Santa Maria River, near Pt. Sal, San Luis Obispo Bay	S.	75	1520–1525	Pandalus jordani, P. platyceros, Spirontocaris bispinosa, Crago communis, C. resima
55	10/23	Off Pismo Beach, San Luis Obispo Bay	W.	85–110	0733–0800	Pandalus jordani
56	10/23	West of Pismo Beach	SW. ½ S.	125–180	0900–0930	Pandalus jordani, P. platyceros
57	10/23	West of Pismo Beach		200–220	1019–1032	Pandalus platyceros
58	10/23	West of Pismo Beach	SE. by S. ½ S.	100	1230–1309	Pandalus jordani, P. platyceros
61	10/23	West of Pismo Beach	S. by W.	68	1651–1722	Pandalus jordani, P. platyceros
62	10/24	Off Pismo Beach	SE. by S. ¼ S.	76–78	0718–0755	Pandalus jordani, P. platyceros
63	10/24	Off Point San Luis		75–78	0901–0917	Pandalus jordani, P. platyceros
64	10/24	Off Lion Rock, just south of Point Buchon	NW. by ½ W.	80	1020–1035	Pandalus jordani, P. platyceros
65	10/24	Between Point Buchon and Point San Luis	NE. ½ E.	90–70	1302–1320	Pandalus jordani, P. platyceros
66	10/24	West of Oso Flaco, San Luis Obispo Bay	SE. by S. ¼ S.	78	1432–1449	Pandalus jordani, P. platyceros
67	10/24	One mile SE. of Oso Flaco		76	1527–1543	Pandalus platyceros
68	10/24	Off Oso Flaco	W. by S. ½ S.	70–75	1639–1646	Pandalus platyceros

69	10/25	Off Point San Luis	SE. by S.	80	0722–0755	Pandalus jordani, P. platyceros
70	10/25	Off Oso Flaco	SW. ¼ W.	70–92	0813–0905	Pandalus jordani, P. platyceros
71	10/25	Off Pismo Beach	NW. by N. ¼ N.	81–83	0955–1055	Pandalus jordani, P. platyceros
72	11/5	Off Pismo Beach	SW. by S. ½ W.	90–70	0940–0956	Pandalus jordani, P. platyceros, Spirontocaris lamellicornis, Crago communis, C. spinosissima
73	11/5	Off Pismo Beach	NW.	85	1100–1200	Spirontocaris lamellicornis, Crago communis, C. spinosissima
74	11/5	Off Pismo Beach	NW.	80	1255–1325	Spirontocaris lamellicornis, Crago communis, C. spinosissima
75	11/5	Off Pismo Beach	SW.	90–110	1410–1430	Pandalus jordani, Spirontocaris lamellicornis, Crago communis, C. spinosissima
76	11/5	Off Pismo Beach	SE.	100	1525–1545	Pandalus jordani, Spirontocaris lamellicornis, Crago communis, C. spinosissima
77	11/6	Due West of Pismo Beach	SW. by S.	82	0935–1005	Pandalus jordani, P. platyceros, Spirontocaris lamellicornis, Crago communis, C. spinosissima
78	11/6	Due West of Pismo Beach	NNW.	83–84	1045–1132	Pandalus jordani, P. platyceros, Spirontocaris lamellicornis, Crago communis, C. spinosissima
79	11/6	Due West of Pismo Beach	SE. by S. ¼ S.	80	1255–1339	Pandalus jordani, Spirontocaris lamellicornis, Crago communis, C. spinosissima
80	11/6	Due West of Pismo Beach	NW. by N. ¾ N.	82	1417–1515	Pandalus jordani, P. danae, Spirontocaris lamellicornis, Crago communis, C. spinosissima
81	11/7	Due West of Pismo Beach	SE. by S. ¼ S.	80	0837–0907	Pandalus jordani, Spirontocaris lamellicornis, Crago communis, C. spinosissima
82	11/7	Due West of Pismo Beach	NW. by N. ¼ N.	80	0950–1050	Pandalus jordani, Spirontocaris lamellicornis, Crago communis, C. spinosissima
84	11/10	Drakes Bay	SW. by S. ¾ S.	20–23	1123–1149	Pandalus danae, Spirontocaris lamellicornis, Crago nigromaculata
85	11/10	Drakes Bay	NE. by E. ¼ E.	22–19	1231–1245	Pandalus danae, Spirontocaris cristata
86	11/10	Drakes Bay	SW. by S. ¾ S.	20–21	1321–1337	Spirontocaris lamellicornis, S. cristata, Crago nigromaculata

TABLE 2

Species Association and Depth Occurrence of Prawns and Shrimp Taken During 1950 by the "N. B. Scofield"

Genus and species	Associate with	At station No. 50B.	Bathymetric distribution in fathoms
Pandalus jordani	Pandalus platyceros	54, 56, 58, 61 to 66, 69 to 72, 77, 78	68–180
	Pandalus danae	80	82
	Spirontocaris lamellicornis	72, 75 to 82	70–110
	Spirontocaris bispinosa	20, 54	75–125
	Crago communis	48, 54, 72 to 82	70–110
	Crago resima	54	75
	Crago spinosissima	72 to 82	70–110
Pandalus platyceros	Pandalus jordani	54, 56, 58, 61 to 66, 69 to 72, 77, 78	68–180
	Spirontocaris lamellicornis	72	70–90
	Spirontocaris bispinosa	54	75
	Crago communis	54, 72, 77, 78	70–90
	Crago resima	54	75
	Crago spinosissima	72, 77, 78	70–90
Pandalus danae	Pandalus jordani	80	82
	Spirontocaris lamellicornis	80, 84	20–82
	Spirontocaris cristata	85	19–22
	Crago nigromaculata	84	20–23
	Crago communis	80	82
	Crago spinosissima	80	82
Spirontocaris lamellicornis	Pandalus jordani	72, 75 to 82	70–110
	Pandalus platyceros	72, 77, 78	70–90
	Pandalus danae	80–84	20–82
	Spirontocaris cristata	86	20–21
	Crago nigromaculata	84, 86	20–23
	Crago communis	72 to 82	70–110
	Crago spinosissima	72 to 82	70–110
Spirontocaris bispinosa	Pandalus jordani	20 to 54	75–125
	Pandalus platyceros	54	75
	Crago communis	54	75
	Crago resima	54	75
Spirontocaris cristata	Pandalus danae	85	19–22
	Spirontocaris lamellicornis	86	20–21
	Crago nigromaculata	86	20–21
Crago nigromaculata	Pandalus danae	84	20–23
	Spirontocaris lamellicornis	84, 86	20–23
	Spirontocaris cristata	86	20–21
Crago communis	Pandalus jordani	48, 54, 72, 75 to 82	70–110
	Pandalus platyceros	54, 72, 77, 78	70–90
	Pandalus danae	80	82
	Spirontocaris lamellicornis	72 to 82	70–110
	Spirontocaris bispinosa	54	75
	Crago resima	54	75
	Crago spinosissima	72 to 82	70–110
Crago resima	Pandalus jordani	54	75
	Pandalus platyceros	54	75
	Spirontocaris bispinosa	54	75
	Crago communis	54	75
Crago spinosissima	Pandalus jordani	72, 75 to 82	70–110
	Pandalus platyceros	72, 77, 78	70–90
	Pandalus danae	80	82
	Spirontocaris lamellicornis	72 to 82	70–110
	Crago communis	72 to 82	70–110

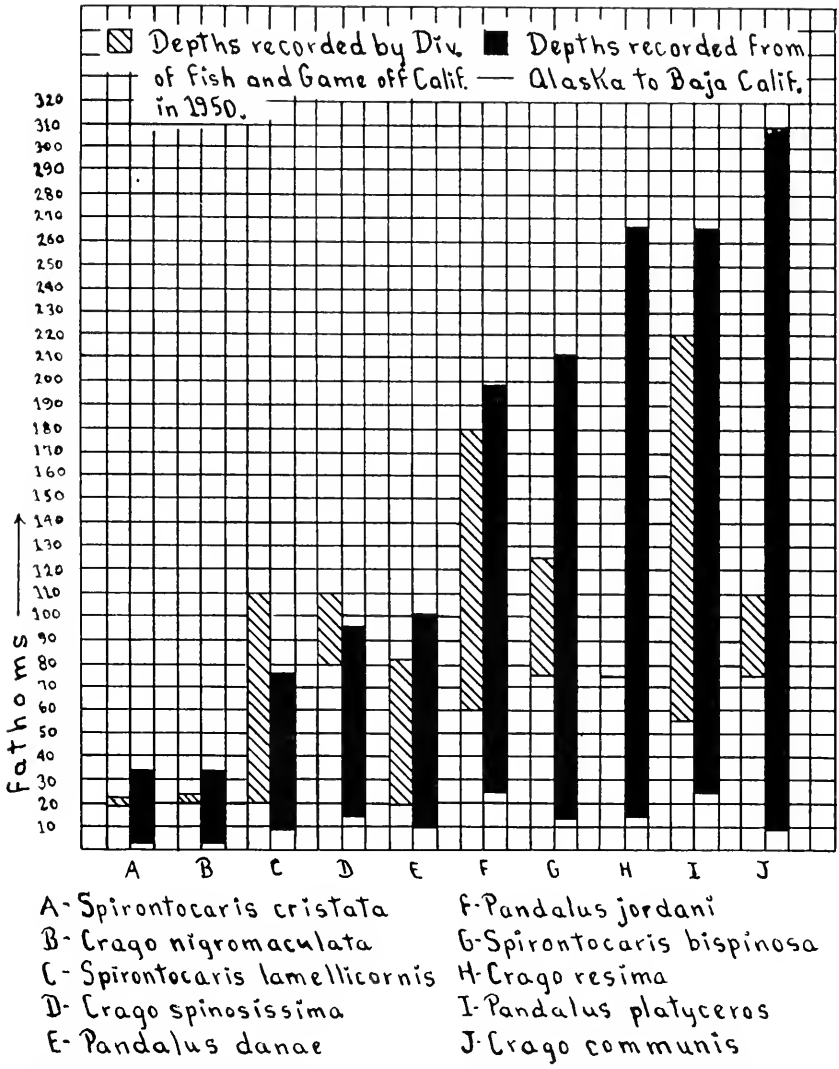

FIGURE 7. Depths recorded on the *N. B. Scofield* in 1950 for shrimp and prowns taken off the California coast compared with depths recorded from Alaska to Baja Califarnia previous to 1950

FAMILY AXIIDAE

Genus *Calastacus* Faxon

Calastacus quinqueseriatus Rathbun

Type Locality: Off San Luis Obispo Bay, 200 fathoms ("Albatross" station 3196).

General Distribution: "Off Point Sur, 298 fathoms; off San Simeon Bay, 160 fathoms; off San Luis Obispo Bay, 252 fathoms; off Point Conception, 233 to 284 fathoms; Santa Barbara Channel, 205 to 280 fathoms; off Anacapa Island, 388 fathoms, and off San Nicolas Islands, California, 1,084 to 1,100 fathoms" (Schmitt).

Collecting Station: West of Pismo Beach, San Luis Obispo Bay (Sta. 50 B.57), 200-220 fathoms, 15 specimens.

Remarks: "Usually taken from 200+ fathoms" (Schmitt).

FAMILY LITHODIDAE
Genus *Lopholithodes* Brandt
Lopholithodes foraminatus (Stimpson)

Type Locality: Off the coast of California near San Francisco.
General Range: "Victoria, British Columbia, to off San Diego, California, to a depth of 299 fathoms" (Schmitt).
Local Distribution: Off Big Flat, north of Shelter Cove, Humboldt County, in 15-21 fathoms.
Collecting Station: Off Big Flat between Stillman (Shipman) and Big Flat Creek (Sta. 50 B.5), 15-21 fathoms, 36 specimens.

Genus *Paralomis* White
Paralomis multispina (Benedict)

Type Locality: Off Queen Charlotte Islands, British Columbia, 876 fathoms ("Albatross" Station 2860).
General Range: "From off Shumagin Bank, Alaska, to off San Diego, California, 625 to 876 fathoms" (Rathbun).
Local Distribution: Off Southeast Farallon Island, 700-820 fathoms.
Collecting Station: Taken 10 miles from Southeast Farallon Island. (Sta. 50 B.88), 700-820 fathoms, 1 specimen.
Remarks: "Known only from 625+ fathoms" (Schmitt).

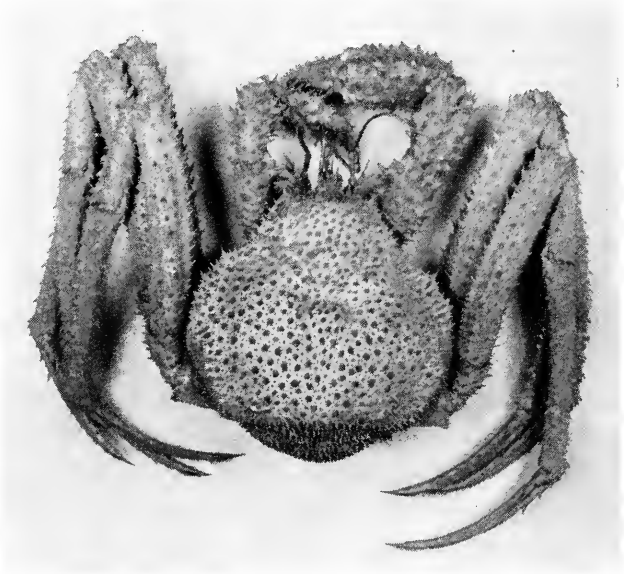

FIGURE 8. *Paralomis multispina*, male; dorsal view. Off Southeast Farallon Island, 700-820 fathoms. *Photograph by Frank L. Rogers, December, 1950.*

Genus *Paralithodes* Brandt
Paralithodes rathbuni (Benedict)

Type Locality: Off San Simeon Bay, California, 211 fathoms ("Albatross" station 3191).

General Range: "Also taken by the 'Albatross' off San Diego, California, 201 to 220 fathoms" (Schmitt).

Local Distribution: Off Pismo Beach, San Luis Obispo Bay, California, 81-83 fathoms.

Collecting Station: Off Pismo Beach, San Luis Obispo Bay (Sta. 50 B.71), 81-83 fathoms, 1 specimen.

Remarks: "Known only from 211 fathoms" (Schmitt). This specimen was found in association with another deep water species, *P. californiensis*.

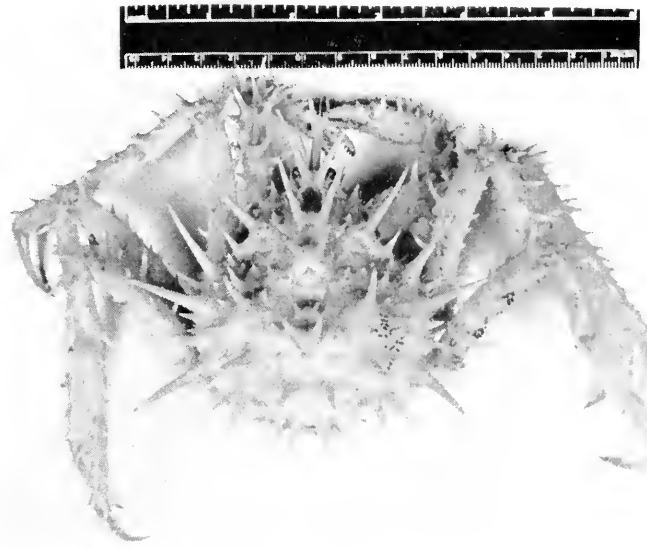

FIGURE 9. *Paralithodes rathbuni*, male; dorsal view. Off Pismo Beach, California, 81-83 fathoms. *Photograph by Frank L. Rogers, December, 1950.*

Paralithodes californiensis (Benedict)

Type Locality: Off Santa Cruz Island, California, 155 fathoms ("Albatross" station 2949).

General Range: "Also taken by the 'Albatross' off San Diego, California, 141 to 167 fathoms" (Schmitt).

Local Distribution: Off Pismo Beach, California in 81-83 fathoms.

Collecting Station: Off Pismo Beach, San Luis Obispo Bay (Sta. 50 B.71), 81-83 fathoms, 3 specimens.

Remarks: "Known only from 155 fathoms" (Schmitt). From this same station *P. rathbuni* was also taken.

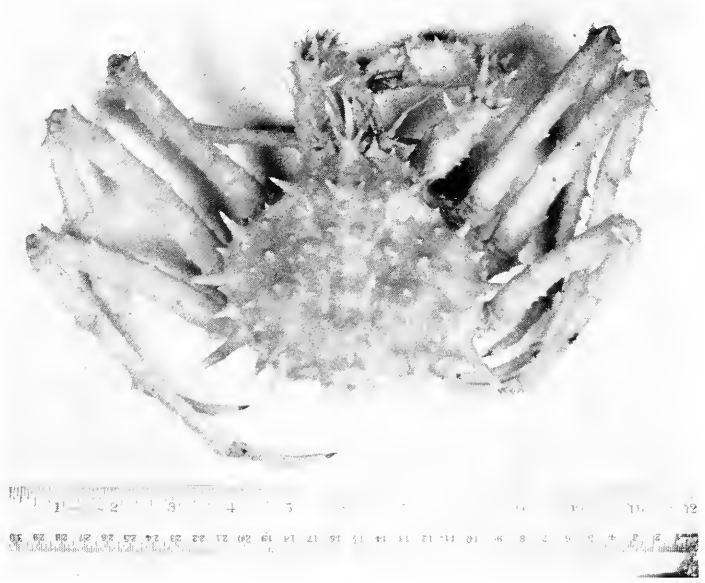

FIGURE 10. *Paralithodes californiensis*, male; dorsal view. Off Pismo Beach, California, 81-83 fathoms. *Photograph by Frank L. Rogers, December, 1950.*

FAMILY CALAPPIDAE

Genus *Mursia* Leach, Desmarest

Mursia gaudichaudii (Milne Edwards)

Type Locality: Coast of Chile.

General Range: "From the Farallon Islands, California, to Chile; 26 to 218 fathoms" (Schmitt).

Local Distribution: Off Pismo Beach, San Luis Obispo Bay, California, 80-110 fathoms.

Collecting Stations: Northwest and southwest of Pismo Beach, San Luis Obispo Bay (Sta. 50 B.72-82), 80-110 fathoms, 2 specimens.

FAMILY INACHIDAE (MAIIDAE)

Genus *Chorilia* Dana

Chorilia longipes Dana

Type Locality: Oregon.

General Range: "From lat. 57° N., off Kodiak, Alaska, to lat. 32° N., off San Diego, California; 27 to 603 fathoms" (Schmitt).

Local Distribution: Delgada Canyon, between Shelter Cove and Big Flat, 285-155 fathoms.

Collecting Station: Delgada Canyon, between Shelter Cove and Big Flat (Sta. 50 B.8), 285-155 fathoms, 2 specimens.

Genus Chionoecetes Kroyer
Chionoecetes tanneri Rathbun

Type Locality: Gulf of Farallones, California, 29 fathoms ("Albatross" station 3100).
General Range: "From Bering Sea to off San Diego, California (lat. 32° 17′ N.); 29 to 1,625 fathoms" (Rathbun).
Local Distribution: 10 miles from southeast Farallon, 700-820 fathoms.
Collecting Station: 10 miles from southeast Farallon (Sta. 50 B.88), 700-820 fathoms, 8 specimens.

FIGURE 11. *Chionoescetes tanneri*, female; dorsal view. Ten miles off Southeast Farallon, 700-820 fathoms. *Photograph by Frank L. Rogers, December, 1950.*

SUMMARY

This report indicates—

1. That the coastal waters of California are capable of providing a new source of supply for the State's minor shrimp fishery.
2. That only a limited quantity of prawns and shrimp exists along the California coast.
3. That restrictions and regulations must be enforced to protect the limited "beds" of prawns and shrimp, the spawning females, and small fishes which may be destroyed by small mesh nets and overfishing.
4. That although most of the prawns and shrimp can be caught with nets, some of the species occur in or near rocky areas inaccessible for trawling, and may necessitate the use of traps.
5. That although the beam trawl was used by the N. B. Scofield at all stations to locate the "beds" of prawns and shrimp, other types of nets are being used elsewhere which offer a more satisfactory solution to the problem of catching shrimp while effectively protecting the young fishes.

6. That all catches of prawns and shrimp were made during the daylight hours. Fishermen of the Gulf States have found their catches to be as much as three times greater by fishing at night for certain species of shrimp.
7. That 10 species of prawns and shrimp were most frequently represented in the catches of the N. B. Scofield along the California coast during the 1950 investigation.
8. That *Pandalus jordani, P. platyceros, P. danae,* and *Spirontocaris lamellicornis* are the only four species known to occur off the California coast at present, which are of large enough size and abundance to be of any commercial value. These species do not include *Crago nigricauda, C. nigromaculata,* and *C. franciscorum,* which have been taken from San Francisco Bay since 1869.
9. That a majority of the prawns and shrimp of commercial value occur at a depth varying from approximately 20 fathoms to 220 fathoms along the coast of California.
10. That, in general, the catches of prawns and shrimp were smaller as the depth increased, but the size increased with the increase in depth. A minimum and a maximum bathymetric distribution apparently exist for each species, and above or below either depth the concentration of the species diminishes rapidly.
11. A southern extension in range for *Pandalus danae* from San Francisco to Pismo Beach, San Luis Obispo Bay, California.
12. A southern extension in range for *Spirontocaris lamellicornis* from Point Arena to Pismo Beach, San Luis Obispo Bay, California.
13. An extension in the bathymetric distribution for *Spirontocaris lamellicornis* from 77 fathoms to 110 fathoms.
14. An extension in the bathymetric distribution for *Crago spinosissima* from 96 fathoms to 110 fathoms.
15. That as a result of the bottom-fish investigation conducted during 1950 by biologists of the N. B. Scofield, the minor California shrimp fishery may expand from the present limited source of supply in San Francisco Bay and San Pablo Bay to the offshore "beds." Research will continue in an attempt to gain additional information concerning the life history of the prawns and shrimp, the biological and physical factors which affect their populations, the extent of the "beds," and the location of new ones.

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THE FLAPJACK DEVILFISH, *OPISTHOTEUTHIS*, IN CALIFORNIA[1]

By S. STILLMAN BERRY
Redlands, California

The cephalopod mollusks, which comprise the squids, cuttlefish, and devilfish, unquestionably are among the most remarkable creatures inhabiting the ocean. Our own fauna must be considerable, yet the knowledge of it is still quite fragmentary. All amaze us in one way or another, but some of them much more than others. The octopods or devilfishes are, in general, far less varied and distinctively specialized than the squids, whereas the latter include some of the strangest animals in existence. The tendency among the octopods is rather to ring countless small changes on the general theme of the common octopus, although included among their numbers are the spectacular paper nautili or argonauts, and the impossible-looking "flapjack devilfishes," as someone has not ineptly termed them, than which the most bizarre squid is not much queerer. Where the bottom conditions are suitable for their existence, animals of this genus, *Opisthoteuthis*, which in the preserved state resemble in about equal degree a soggy pancake or a very dirty floor-mop, are probably not unduly rare and it is likely that certain of our fishermen, notably the shrimp trawlers, may have been aware for some time that such things exist. It is, however, only recently that the occurrence of a species of this genus in Californian waters has been definitely established (Berry, 1949), while the first illustrations of the only two specimens thus far of record are those now presented here.

Figures 1 and 2 show the obvious peculiarities of form and external organization which so clearly set off animals of this genus from the common octopus. One notes the flabby web connecting all the eight arms nearly to their tips like a thick umbrella, the extreme flattening of the mantle and body and their extensive coalescence with the head and web, the relatively enormous swollen eyes, the presence of a pair of inefficient-looking paddlelike fins projecting from the body a short way behind the eyes, and the small suckers ranked in single file on the arms, flanked on either side by alternating series of slender papilla-like cirri. Still more remarkable is the circumstance that the compression of the mantle and body has taken place from the rear forward, and with such urgency that the entire aboral surface has become topographically dorsal,[2] and the ordinarily anterior and ventrally placed funnel is forced completely away from the head and thus has come to lie in a posteriorly directed position on the upper surface of the animal behind the flattened body, where its

[1] Submitted for publication September, 1951.

[2] The apparent dorsality is thus secondary for those regions of the body which are ventral as seen in the octopus. *Pari passu* these same regions become secondarily posterior as well. If one orients the animal's head down, however, less alteration is evident in these relationships.

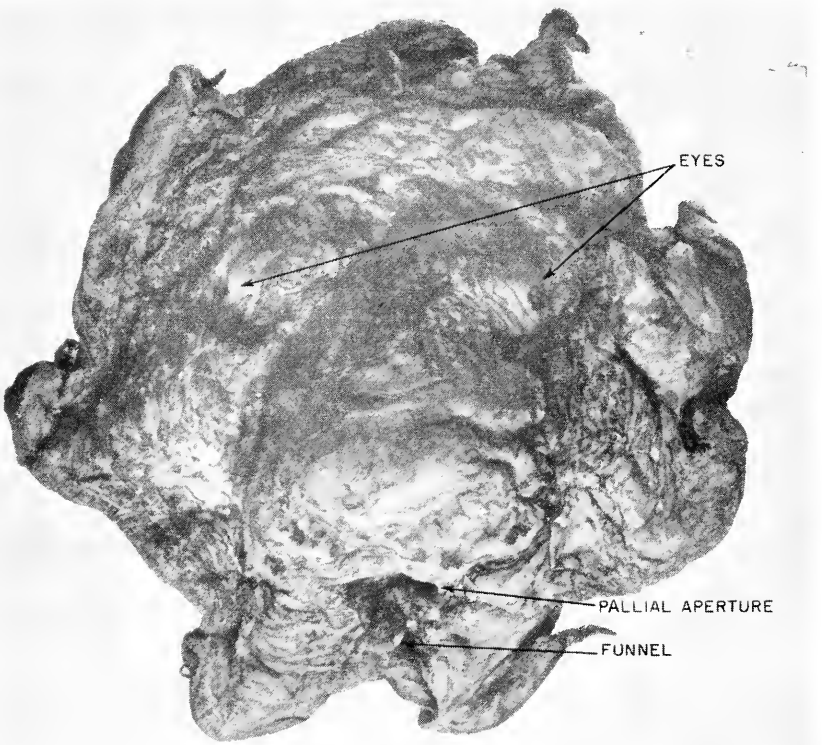

FIGURE 1. *Opisthoteuthis californiana* Berry, oboral view of female holotype (reduced slightly more than one-half)

tubular apex projects through the rounded and much contracted mantle-opening. It consequently appears that in this creature, when jets of water are squirted from the funnel, the normal mode of progression is forward, contrariwise to the octopus where it is backward The direction might conceivably be subject to change should the animal bend the funnel upward and forward, but in an animal formed like *Opisthoteuthis* this would appear rather an awkward undertaking and, except in some emergency, not too effective or oftenmuch relied upon. Furthermore we do not know how great a part of the locomotory activity may be contributed by the undulation or the opening and closing of the arms and umbrella—one suspects that it may be quite a bit, especially if the animal is the bottom dweller that it looks to be. Observation of living animals in even an improvised aquarium should afford enlightenment upon this point and also upon the balancing or other function of the very inadequate appearing fins.

If one opens up the mantle cavity of an *Opisthoteuthis* the arrangements there disclosed are quite as novel as the rest of the animal, not merely because of altered topographical relationships but because so many structures usually considered essential to cephalopod organization

FIGURE 2. *Opisthoteuthis californiana* Berry, oral view of female holotype (reduced slightly more than one-half)

are here quite lacking. One discovers no radula, no salivary glands, no well defined crop, no ink sac, no right oviduct (Meyer, 1906:27, 30, 63). Whole organs are lost, yet one notices no new constructions to replace them. The changes seem in the direction of reduction and simplification almost throughout. The most conspicuous feature in the internal anatomy of the mature and gravid female is the massive and relatively enormous ovary, which is so firmly constructed that when explored by mere palpation it still seems to constitute the main strength and bulk of the body. Even the oviduct is extraordinarily thick and heavy, its terminal portion visible externally as a conspicuous whitish larva-like object sheltered just within the pallial opening (Figure 4). When the ovary is laid open or broken a mass of ova is revealed (Figure 5), varying from a great number of relatively elongated and minute eggs in an early stage of development to a comparatively small number of larger ones upon the point of extrusion which break away readily and then are found scattered about in the surrounding preservative. The largest egg measured by me is 9 mm. long by about 5 mm. in its greatest diameter.

Seven species pertaining to this genus have now been discovered and described, of which two are from the Atlantic, one is from the Indian Ocean, one is Japanese, and two are Australian. Our species, which has been named *O. californiana* (Berry, 1949:23) is the first of the group to be found in the eastern Pacific, and seems by its characters more closely allied to the Japanese and one of the Australian species (subgenus *Teuthidiscus* Berry, 1918:284) than it does to the genus-type from the Atlantic (Verrill, 1883). The special features characterizing *O. californiana*, although apparently tangible and adequate for its separation, are relatively slight. As the male sex in cephalopods is generally subject to stronger and sharper specific differentiation than the females, the discovery of the still unknown males of our species may well reinforce the differences and throw additional light on the problem of its relationships. Since the more important diagnostic characters as presently known have already been set forth elsewhere (Berry, 1949) it is unnecessary to repeat them here, though a few supplementary observations may not be out of place.

The color of the upper surface of our specimens, as preserved in alcohol, is a light dull drab, very heavily concentrically streaked with dull dark reddish brown, but as is well shown in Figure 4, the major breaks in the general ground-color may be due to damage consequent to inevitable rough treatment in the trawl and represent but abrasion or splitting of the delicate outer skin. If this be true we should expect the dark color in life to be more evenly distributed, perhaps somewhat as we find it on the oral surface where the uniform purplish-drab field is broken only by the lighter suckers and cirri and the still paler central portions of the arms (Figures 2 and 3). The fresh color may likewise be more purplish or reddish than is now the case. The mouth, sufficiently open

FIGURE 3. *Opisthoteuthis californiana* Berry, oral aspect of second and third right arms of female holotype (slightly enlarged)

FIGURE 4. *Opisthoteuthis californiana* Berry, oblique view of funnel and pallial aperture, the former pushed somewhat to the left to reveal the terminal portion of the oviduct (halotype, considerably enlarged)

to reveal the strong black beak, is a conspicuous feature where the arms meet at the center of the disk. I have discovered in this species no trace of the radially arranged areolar spots which appear so conspicuously on the aboral surface of several congeners, and it is not known whether the examination of fresher examples would reveal them. The maximum (lateral) spread of the larger individual in hand (S.S.B. 859) is about 360 mm. Further detailed measurements of both specimens are set forth on page 25 of my preliminary paper.

From direct observation we apparently know nothing whatever concerning the food or general manner of life of these animals. A little is suggested to us by their gross morphology, but this after all is only surmise. The presence of the radial series of cirri converging to the mouth might suggest that *Opisthoteuthis* feeds mainly on microplankton or detritus swept down the disk toward the mouth, but if this be true the persistence of the powerful mandibles after the loss of the radula becomes thereby less easy to explain. It is to be hoped that we may not have long to wait before further examples of so strange and interesting an animal will be captured and that something may then be learned of its appearance in the living state, its behavior and habits. Likewise, as has already been indicated, the recovery of males will in itself yield much additional information of value to our understanding of the species.

FIGURE 5. *Opisthoteuthis californiana* Berry, pallial chamber and ovary of paratype laid open to show ripe ova and others in various stages of development (x2)

Due credit must be given to Mr. N. Franklin of the boat ANDREW JACKSON who took the present specimens in 188 fathoms, NW. by W. of Eureka Bar, California, April 25, 1948, as well as to Mr. William E. Ripley of the California Department of Fish and Game who transmitted them to the Natural History Museum of Stanford University, whence, through the kindness of Drs. George S. Myers and Margaret Storey, they were submitted to the writer for study and report. The photographs were made by Mr. Edgar R. Fisher of Redlands.

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THE NORTHERN ANCHOVY (*ENGRAULIS MORDAX MORDAX*) IN THE CALIFORNIA FISHERY[1]

By FRANCES N. CLARK and JULIUS B. PHILLIPS
Bureau of Marine Fisheries
California Department of Fish and Game

INTRODUCTION

Throughout the years the fishery for the California anchovy, although a minor one, has been of considerable importance to a limited group of fishermen, especially in Southern California. With the failure of the sardine fishery in 1945-46, fishermen and processors in Central California turned to other resources and gave serious consideration to possible uses of the anchovy. This resulted in trebling the tonnage in 1947, as indicated in Table 1, and emphasized the need for information about the abundance and biology of the species.

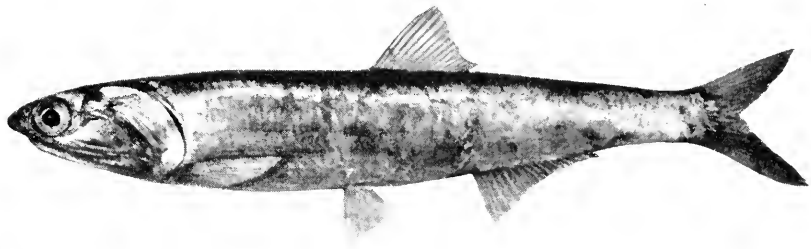

FIGURE 1. The northern anchovy

The northern anchovy is found from British Columbia to Southern Baja California. The extent of migrations within this range is not definitely known at present although McHugh (1951) concluded that three populations occur, one from British Columbia to Northern California, one off Southern California and Northern Baja California, one off Central and Southern Baja California, and that these populations do not intermingle completely.

During the past five years the staff of the Bureau of Marine Fisheries has accumulated considerable data about the biology and the fishery which are here compiled. The results are far from complete but the information at hand is published here to make it available to all who may have an interest therein. Many of the samples of anchovies and original measurements were collected by staff members other than the authors and their contributions to the study are much appreciated and gratefully acknowledged.

[1] Submitted for publication January, 1952.

TABLE 1

Tons and Numbers of Anchovies Taken in the California Fishery

Year	Southern California				Northern California		State total	
	Shore landings, tons	Live bait fishery, tons	Total		Shore landings		Tons	Numbers
			Tons	Numbers	Tons	Numbers		
1939	961	1,503	2,464	135,520,000	113	2,599,000	2,577	138,119,000
1940	3,133	2,006	5,139	282,645,000	26	598,000	5,165	283,243,000
1941	2,036	1,582	3,618	198,990,000	17	391,000	3,635	199,381,000
1942	770				87	2,001,000		
1943	647				139	3,197,000		
1944	1,467				479	11,017,000		
1945	598				210	4,830,000		
1946	705	2,748	3,453	189,915,000	256	5,888,000	3,709	195,803,000
1947	1,525	2,854	4,379	240,845,000	7,945	182,735,000	12,324	423,580,000
1948	1,593	3,725	5,318	292,490,000	3,825	87,975,000	9,143	380,465,000
1949	812	3,293	4,105	225,775,000	850	19,550,000	4,955	245,325,000
1950	996	3,824	4,820	265,100,000	1,443	33,189,000	6,263	298,289,000

Table 1 gives tons landed in Northern and Southern California from 1939 through 1950. The tonnages for Northern California include landings from the Oregon line south to the Monterey-San Luis Obispo County line and for Southern California the remainder of the State. The live bait tonnages comprise records of bait taken for sport fishing only. Records of live bait used by the commercial fisheries are not available. During World War II lack of personnel precluded getting records from the fishermen taking bait for the sport fishery and there are no figures for 1942-1945.

THE FISHERY

Central California

Anchovy fishing in Central California is carried on by the same type of boat and the same type of net as used in sardine fishing, namely, purse seines, "half-ring" or ringnets, and lampara nets. Anchovies are found in the same general areas as are sardines, but perhaps not quite as far out to sea. Five to six miles offshore is usually as far out as catches of anchovies are made. The greater proportion of the landings at both San Francisco and Monterey are a result of catches made within 25 miles of port. There have been times, however, when the Monterey boats have gone as far north as the Farallones, some 75 miles northward of Monterey, for anchovies, but long-hauling is discouraged because these fish are delicate and require careful handling.

Each year a nominal amount of anchovy is salted in Central and Northern California for bait for long line fishermen. A small amount of the salted product is sometimes used for human consumption. Previous to 1946, the canning of anchovies in California was tried on an experimental basis. Because of a scarcity of sardines in Central California starting in 1946, the canning of anchovies, on a moderate but sustained basis, commenced in that year.

In 1946, about 1,500 cases of anchovies were canned, all at Monterey. In 1947 about 180,000 cases were canned at Monterey, 2,400 cases at San Francisco and 75 cases at San Pedro. In 1948 approximately 121,000 cases were packed, Monterey accounting for 87 percent of this total and San Pedro packing the balance. In 1949 about 4,500 cases were packed, 40 percent at Monterey, the balance at San Pedro. In 1950 nearly 50,000 cases were packed, all at Monterey and in 1951 about 90,000 cases all at Monterey. Part of the anchovy pack has been shipped to the Philippines and part sold on the domestic market.

Near the end of 1947, the canned anchovy market weakened, and some plants canned less and turned more whole fish into straight reduction. In order to discourage this unnecessary reduction of whole fish into meal and oil, the California Fish and Game Commission issued the following regulation, to become effective April 1, 1948:

"Each packing plant processing anchovies shall produce from each ton of anchovies received in his plant for canning during each calendar month not less than the following number of cans:

No. 10 or 10-lb.	(6 cans to case)	120 cans	(20 cases)
1-lb. tall or oval	(48 cans to case)	864 cans	(18 cases)
½-lb. oval or 9-oz. oblong	(48 cans to case)	1,344 cans	(28 cases)
½-lb. round	(48 cans to case)	1,584 cans	(33 cases)
¼-lb. oblong	(100 cans to case)	2,600 cans	(26 cases)

"Any canner of anchovies desiring to pack in cans of a size or style not listed above must submit samples of the pack to the commission, and secure the acceptable equivalent before engaging in packing such size or style of pack."

This regulation requires that each packer place a high proportion of each ton of anchovies in cans and lowers the amount reduced as offal. Because of this requirement packers can accept only anchovies which have been carefully handled by the fishermen and brought to the processing plants within a few hours after capture. Consequently the daily catch of each fishing vessel is limited since a large load results in crushing and breaking the anchovies at the bottom of the load and rendering them unfit for canning.

In addition to the types of cans listed in the regulations above, a few hundred cases of $2\frac{1}{2}$-lb. cans, 12 cans to the case, were packed in 1949. In 1951, some 6-oz., round cans, were packed. The most popular pack has been the $\frac{1}{2}$-lb. can with tomato sauce added.

Between 1919 and 1921, there was some reduction of whole anchovies into oil and meal. In 1919, a state law was passed which prohibited the reduction of whole fish except under permit, but it was not until 1921 that "teeth" were put into the law and further reduction of anchovies prohibited. In May, 1943, 100-ton permits to reduce anchovies on an experimental basis were granted to one plant at Monterey and to two plants at San Francisco. These permits were not entirely used, however, and it was thought that further experimentation would be necessary before anchovies could be successfully reduced to oil and meal.

Southern California

Anchovy fishing in Southern California is carried on almost exclusively by fishermen using small boats and lampara nets. Consequently the catch is made within a few miles of shore in relatively shallow water. The live bait fishermen, who supply over half of the Southern California tonnage, operate along the coast from Ventura to San Diego. These men fish during the night and early morning, transfer their catch from the net to a bait tank, and deliver the live fish to the sport fishing boats as the latter are leaving for the fishing grounds. Fish other than anchovies are also taken in the live bait fishery but only anchovy tonnages are discussed in this report. The records of tonnages taken by this fishery, as given in Table 1, are supplied by the captains of the bait boats who record, by species, the number of scoops of bait taken in each net haul. The staff of the Bureau of Marine Fisheries converts the number of scoops into poundage and tonnage by a conversion factor obtained by weighing scoops of bait on the various bait boats.

The shore landings of anchovies are made at the wholesale fish markets and at the canneries. A few attempts have been made to can anchovies in Southern California but practically all tonnages delivered to the canneries are ground and resold to the mackerel scoop boats to be used as bait in the Pacific mackerel fishery. Anchovies sold to the wholesale fish markets are used chiefly as cut bait, both salted and frozen, in the commercial hook and line fishery and to some extent by sportsmen fishing from piers and in the surf. In addition anchovies are frozen and used as supplemental food for trout in the state hatcheries. The amount of anchovies taken by the shore dealers of Southern California has varied

considerably during the past 12 years. The major cause lies in fluctuating demands for dead bait.

The use of anchovies in Southern California for live bait fishing has shown a relatively steady increase since the first records were obtained in 1939. This in turn reflects the rapid expansion of marine recreational fishing in these waters. This bait fishery furnishes the only statistics which yield a satisfactory measure of the return per unit of effort expended and thus an estimate of the relative abundance of the anchovy population on the grounds where the live bait boats operate.

TABLE 2

Number of Scoops per Haul in the Southern California Live Bait Fishery

Year	Number of scoops	Number of hauls	Scoops per haul
1939	176,850	6,946	25.46
1940	235,996	10,021	23.55
1941	186,079	7,745	24.03
1942	30,300	1,207	25.10
1946	323,310	7,543	42.86
1947	421,058	10,583	39.79
1948	499,377	11,951	41.79
1949	392,009	11,408	34.36
1950	526,878	10,520	50.08

The yearly total of scoops of anchovies taken, for which records are available, and the number of hauls required to yield these are given in Table 2. The number of scoops per haul indicate the changing trends in the yield. Prior to World War II the bait fishermen were catching about 25 scoops per haul. In the postwar years fishing techniques were improved rapidly by the introduction of lights to attract the fish and fathometers to locate and estimate the size of the schools (Young, 1950). These improvements in techniques appear to have increased the yield of anchovies from about 25 scoops per haul in the prewar years to approximately 40 scoops in the postwar fishery. Since 1946 there has been no consistent increase and the data suggest that the yield cannot exceed this level for any extended time interval and that the Southern California anchovy population is now being exploited at the highest practical level to assure a maximum and continued yield.

BIOLOGY

Size of Anchovies in the Catch

Samples of the Monterey anchovy catch delivered to the canneries were collected between September 1946 and November 1951. These comprise 5,420 anchovies from 105 different samples. In Southern California similar samples were taken from the live bait fishery between December 1947 and August 1951 and include 2,000 anchovies from 19 different samples. From the fish in these samples measurements were made in millimeters of standard length and total length. Weights of individual fish and of the total sample were recorded, scales for age determination were taken, and observations were made on the state of maturity.

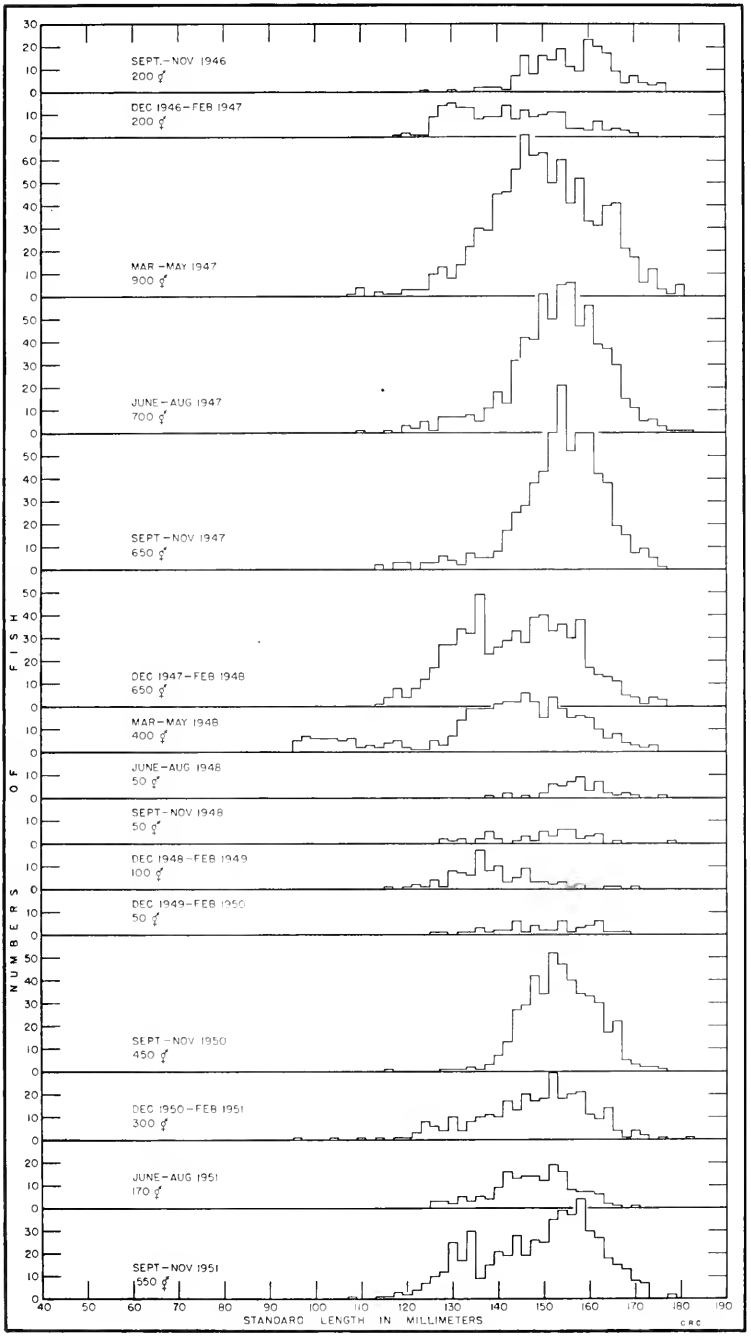

FIGURE 2. Length frequency polygons of anchovies taken in the Monterey fishery

The length measurements were compiled into frequencies at each 2 mm. and grouped into three-month intervals as follows:

December-February	(winter)
March-May	(spring)
June-August	(summer)
September-November	(fall)

The resulting frequency polygons for Monterey (Figure 2) show that the largest anchovy measured was 184 mm. and the smallest 96 mm., standard length, or 8.5 and 4.4 inches, total length, with an average of 148.8 mm., standard length, or 6.9 inches total length. Throughout the spring and summer of 1947, when the most consistent sampling was carried on, there was some suggestion of a progressive size increase with a regression in the following fall and winter. Data are too fragmentary in the succeeding years to give additional information on this. As with many fishes the female anchovy reaches a greater maximum size than does the male. The largest male was 174 mm. and the largest female 184 mm.

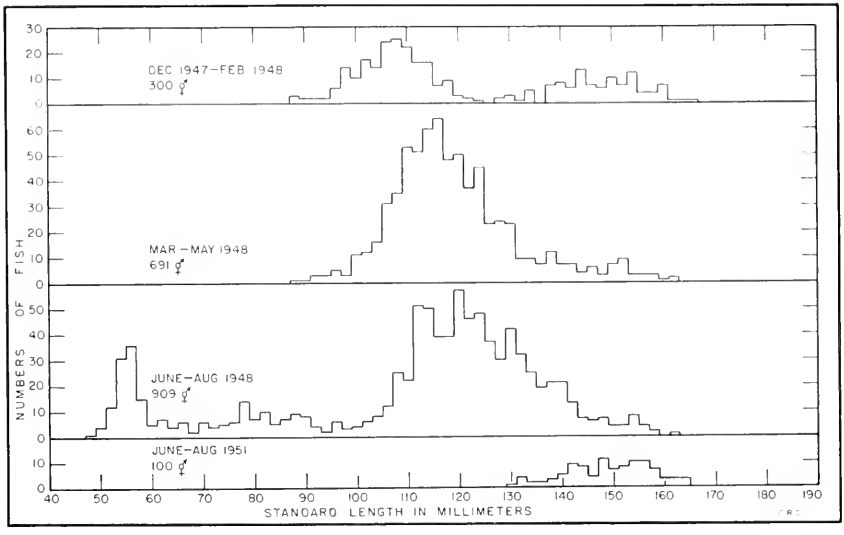

FIGURE 3. Length frequency polygons of anchovies taken in the Southern California bait fishery

Anchovies in the Southern California bait fishery were markedly smaller than those taken at Monterey (Figure 3). In this fishery lengths range from 48 to 166 mm., standard length, or 2.3 to 7.6 inches total length, with an average of 116.4 mm. or 5.3 inches, total length. As in 1947 at Monterey, there is some suggestion of a size increase during the spring and summer of 1948. The group of small fish 50-70 mm., obviously fish of the year, and the group 70-90 mm., probably also fish of the year, were taken during the summer. These small anchovies occurred in samples collected from Ventura to Oceanside. The single sample of 100 large fish obtained in the summer of 1951 was taken off Hueneme and

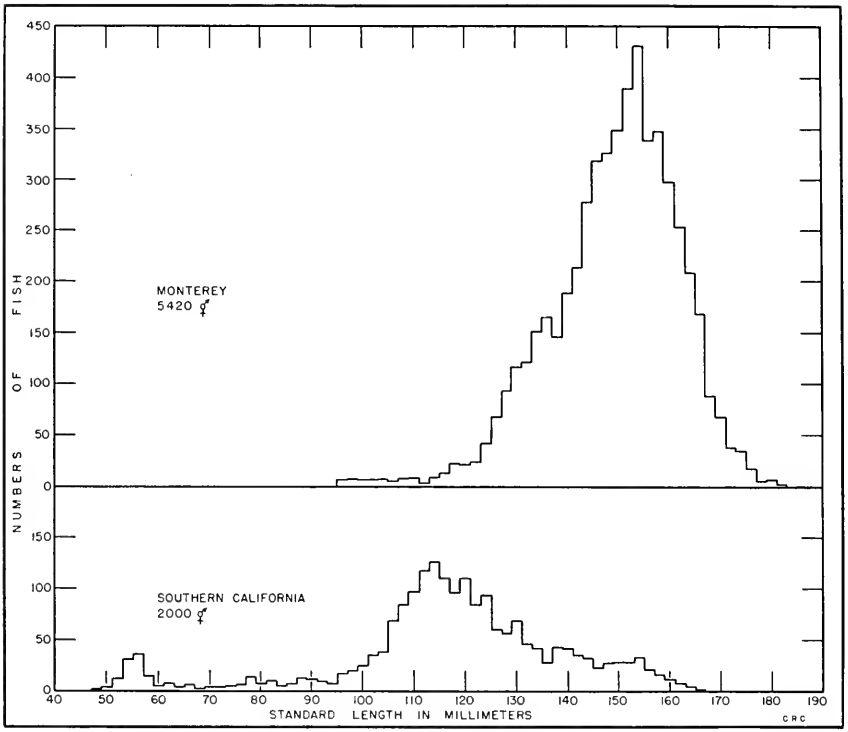

FIGURE 4. Length frequency polygons of all anchovies measured at Monterey and in the Southern California bait fishery

the anchovies larger than 130 mm. in the December 1947-February 1948 collections also came from the Hueneme fishery. This coupled with the occurrence of larger fish at Monterey might suggest that anchovies increase in size northward along the California coast. Very small anchovies, however, were also taken in the neighborhood of Hueneme and fish between 140 and 160 mm. occurred as far south as Oceanside. From the data at hand, therefore, the reasons for the size differences between Monterey and Southern California samples are not clear. They may result from a faster growth rate in Central California, from incomplete sampling or from the fact that the bait fishermen operate closer to shore than do the Monterey fishermen. As at Monterey the females in the Southern California samples attain a larger size than the males, the maximums being 166 and 160, mm., respectively. The ratio of females to males was 1.4 at Monterey and 1.2 in Southern California. For the entire Pacific Coast McHugh's (1951, table 1) data indicate a ratio of 1.3.

Weight-Length Relationship

Calculations of the relation between weight and length were based on the average weight and the average length of each sample. There were 77 samples from Monterey and 17 from Southern California for which weights were available. These gave for Monterey a formula for the

weight-length curve of $W = .00000719L^{3.2521}$ for fish ranging from 114 to 160 mm. and for Southern California, $W = .000269L^{3.4529}$, for fish ranging from 56 to 134 mm. Although the constants in these two formulae differ, the resulting calculated values for weight at specific lengths yielded only small differences between the anchovies from the two areas. Consequently the data for the two regions were combined and a new weight-length curve calculated from the formula, $W = .000333L^{3.4074}$ The resulting values (Table 3) give the number of fish per ton at each 5 mm. of standard length with the corresponding total length in inches as well as the weight per fish in ounces. Total length was calculated by multiplying standard length in millimeters by 1.17111 and converting to inches. The factor 1.17111 was obtained from total and standard length length measurements made on 58 anchovies selected from the Monterey and Southern California data and ranging in size from 95 to 175 mm., standard length.

TABLE 3

Number of Anchovies per Ton at Each Five Millimeters of Standard Length

Standard length, mm.	Total length, inches	Fish per ton	Weight per fish, ounces
50	2.3	977,000	.033
5	2.5	706,000	.045
60	2.8	525,000	.061
5	3.0	400,000	.080
70	3.2	310,000	.103
5	3.5	245,000	.130
80	3.7	197,000	.162
5	3.9	160,000	.200
90	4.2	132,000	.243
5	4.4	110,000	.292
100	4.6	92,000	.347
5	4.8	78,000	.410
110	5.1	67,000	.481
5	5.3	57,000	.559
120	5.5	49,000	.647
5	5.8	43,000	.743
130	6.0	38,000	.849
5	6.2	33,000	.966
140	6.5	29,000	1.093
5	6.7	26,000	1.233
150	6.9	23,000	1.383
5	7.2	21,000	1.546
160	7.4	19,000	1.723
5	7.6	17,000	1.914
170	7.8	15,000	2.118
5	8.1	14,000	2.339
180	8.3	12,000	2.576
5	8.5	11,000	2.827

The average length of all fish measured at Monterey was 148.8 mm. which would yield 23,000 fish per ton and in Southern California 116.4 mm., approximately 55,000 fish per ton. From these values of average number of fish per ton the total catch was converted into numbers as given in Table 1.

Although the tonnage of anchovies taken in the California fishery is relatively small, the total numbers are not insignificant. In comparison with the sardine fishery, the 1950-51 sardine catch totaled 350,548 tons

and 2,589,569,000 fish (Felin et al. 1951, p. 348). This exceeded the 1950 anchovy tonnage by 56 times but the anchovy numbers by only 8.7 times. The Pacific mackerel catch in 1950-51 comprised 15,920 tons and 40,063,000 fish (Fitch, 1951, Table 15, Roedel, 1952, Table 2). The tonnage was 2.5 times the 1950 anchovy catch, but the numbers of anchovies taken exceeded the number of mackerel by over seven times.

Age and Growth

Age and growth of the northern anchovy were ascertained from scales. Although scales for age readings were taken at different times of the year, for this preliminary study, only scales collected during the months of minimum growth, October-February, were used and the margin of the scale was considered as approximately the last annulus.

Anchovy scales are of the clupeoid type, sculptured on the outer surface of the unexposed part. They lend themselves to the same method of handling as sardine scales. That is, after cleaning, several scales from one fish are mounted, dry, between two glass slides taped together at the ends. The image of a scale is projected to a diameter of about 45x. For each fish aged a ruled card is marked to indicate position of annuli and the margin of the scale. Anchovy scales are somewhat more difficult to interpret as to age than are sardine scales. This is because of the presence of accessory annuli-like bands in some scales.

A preliminary interpretation of age was made on scales representing 211 fish of all sizes taken in the Monterey fishery. The oldest fish found had completed seven years of life. The length frequencies, by age classes, at time of capture for males and females and for the sexes combined, are shown in Table 4. Males averaged a few millimeters less in length than did females.

For comparison with the lengths at time of capture, calculations of lengths of fish, at time of formation of annuli previous to time of capture, were made (Table 5). These calculations are based on a straight line relationship between scale length and length of fish. The dispersion of sizes in each age group, as shown in Tables 4 and 5, is considerable, and may reflect a protracted spawning period, as well as a difference in growth due to environmental conditions.

Both the lengths at time of capture and calculated lengths are approximately the same for ages four, five and six for the combined sexes. For ages of less than four, however, the calculated lengths gave a progressively smaller value than did the lengths at time of capture. This may be due to errors in interpretation of annuli in younger fish because the annuli do not become clearly evident until additional annuli are laid down, or it is possible that recruitment into the Central California fishery is not fully completed until the fourth year.

Since average sizes for years four, five and six were practically identical for both the time at capture and for the calculated sizes, the graphic growth method, as developed by Walford (1946), was applied to average size at time of capture for ages four, five and six to obtain the "transformation" for most probable average lengths at ages one, two, three and seven. These adjusted, or most probable average lengths at each age in the California fishery, are given in Table 6 and in Figure 6.

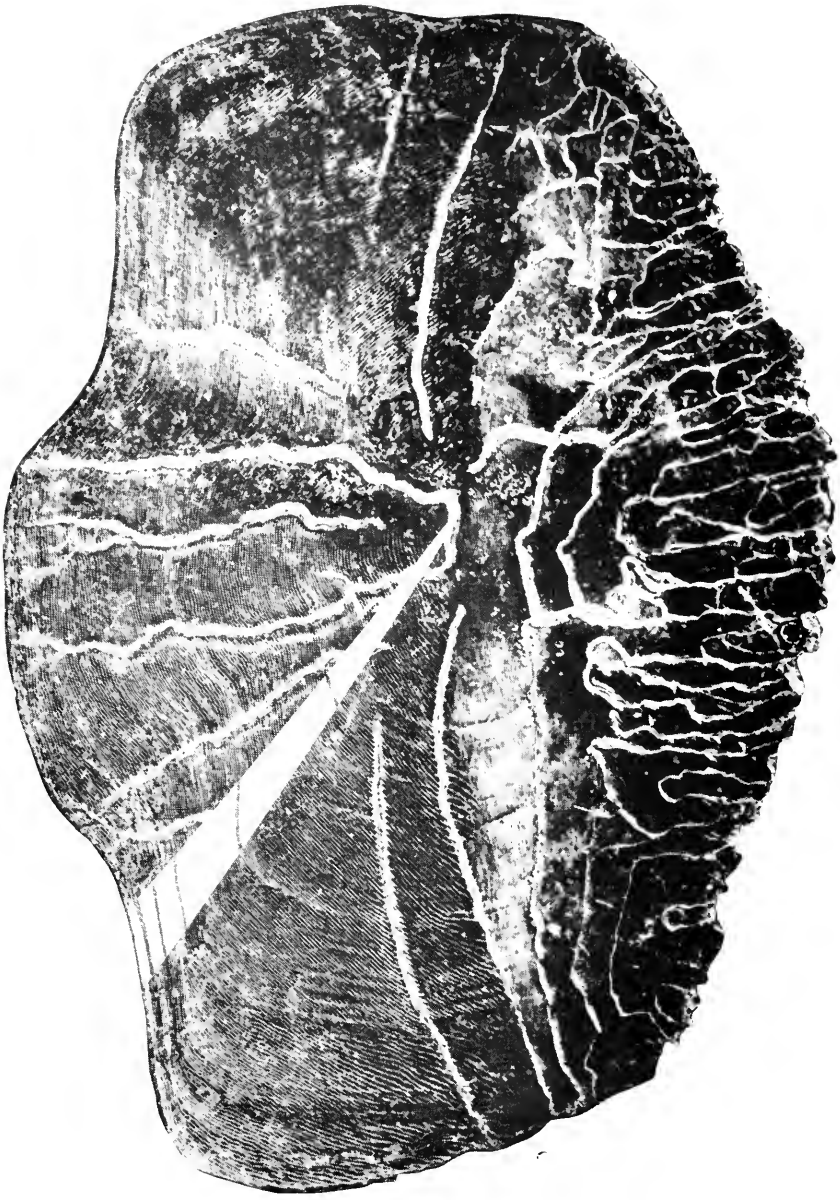

FIGURE 5. Anchovy scale with five annuli, from fish 168 mm. standard length, caught in Monterey Bay, September 22, 1950. *Photograph by D. H. Fry, Jr.*

TABLE 4

Length Frequencies of Anchovies, by Age Class, at Time of Capture

Standard length mm.	Age in years																							
	1			2			3			4			5			6			7		
	M.	F.	T.	M.	F.	T.	M.	F.	T.	M.	F.	T.	M.	F.	T.	M.	F.	T.	M.	F.	T.
88	1	--	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
90	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
92	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
94	1	--	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
96	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
98	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
100	--	1	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
102	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
104	--	1	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
106	--	1	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
108	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
110	1	--	1	1	--	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
112	--	--	--	--	1	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
114	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
116	1	--	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
118	1	--	1	--	1	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
120	--	--	--	--	1	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
122	1	--	1	3	1	4	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
124	2	1	3	1	--	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
126	--	1	1	3	1	4	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
128	--	3	3	--	2	2	1	--	1	--	--	--	--	--	--	--	--	--	--	--	--
130	--	--	--	3	1	4	2	--	2	1	--	1	--	--	--	--	--	--	--	--	--
132	--	--	--	1	2	3	--	1	1	--	--	--	--	--	--	--	--	--	--	--	--
134	--	--	--	1	2	3	1	--	1	1	--	1	--	--	--	--	--	--	--	--	--
136	--	--	--	1	1	2	--	2	2	1	--	1	--	--	--	--	--	--	--	--	--
138	--	--	--	1	1	2	1	1	2	3	--	3	--	--	--	--	--	--	--	--	--
140	--	--	--	--	2	2	--	3	3	2	--	2	--	--	--	--	--	--	--	--	--
142	--	--	--	--	--	--	1	2	3	1	--	1	--	--	--	--	--	--	--	--	--

144							3		3	1	1	2									
146							3	3	6	3	2	5	1		1						
148								1	1	1	1	2	2		2						
150							2	2	4		3	3	1		1						
152								2	2	2		2	1	1	2	1		1			
154								2	2	2	6	8	2	1	3	1		1			
156							1		1	3		3	2		2		1	1			
158											1	1	3		3		1	1		1	1
160										1	6	7	2	4	6	1	1	2			
162										1	1	2		4	4	3	1	1		1	1
164											3	3	1	4	5	1		1			
166											2	2		5	5	1		1			
168													1	1	2	2	1	3			
170													2	1	3	1	1	2	1		1
172														2	2		2	2		3	3
174																	3	3	1	1	2
176																	1	4		2	2
178																	1	1		2	2
180																					
182																					
184																				1	1
Totals	8	8	16	15	16	31	15	19	34	23	26	49	18	23	41	11	16	27	2	11	13
Average length mm.	112	118	115	127	129	128	142	144	143	146	156	152	157	164	161	163	170	167	172	173	173

TABLE 5

Calculated Length Frequencies of Anchovies at Time of Formation of Annuli

Standard length mm.	Age in years																	
	1			2			3			4			5			6		
	M.	F.	T.	M.	F.	T.	M.	F.	T.	M.	F.	T.	M.	F.	T.	M.	F.	T.
40	--	1	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
42	--	1	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
44	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
46	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
48	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
50	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
52	1	1	2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
54	1	1	2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
56	1	1	2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
58	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
60	--	2	2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
62	2	3	5	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
64	2	4	6	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
66	1	4	5	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
68	5	6	11	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
70	7	3	10	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
72	5	4	9	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
74	5	4	9	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
76	5	5	10	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
78	2	1	3	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
80	8	9	17	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
82	3	4	7	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
84	3	7	10	--	1	1	--	--	--	--	--	--	--	--	--	--	--	--
86	2	6	8	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
88	3	9	12	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
90	7	6	13	1	2	3	--	--	--	--	--	--	--	--	--	--	--	--
92	5	4	9	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
94	6	5	11	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
96	3	2	5	2	5	7	--	--	--	--	--	--	--	--	--	--	--	--
98	2	5	7	3	1	4	--	--	--	--	--	--	--	--	--	--	--	--
100	1	3	4	1	3	4	--	--	--	--	--	--	--	--	--	--	--	--
102	4	5	9	4	4	8	--	--	--	--	--	--	--	--	--	--	--	--
104	1	1	2	2	1	3	--	--	--	--	--	--	--	--	--	--	--	--

106		1	1	5	5	10													
108		1	1		4	4													
110		1	1	6	2	8		1	1										
112				1		1	1		1										
114		1	1	5	4	9													
116				4	4	8													
118				2	3	5		1	1										
120				6	5	11		1	1										
122				2	6	8	2		2										
124				3	6	9	1	2	3										
126				6	5	11	7	1	8										
128				6	8	14	2		2										
130				2	10	12	2	5	7	4		1							
132				6	2	8		8	8										
134				1	3	4	4	1	5										
136				1	3	4	8	3	11		2	2							
138					4	4	4	3	7	2		2							
140					3	3	4	5	9		1	1							
142							3	3	6	1	1	2							
144					1	1	1	8	9	3	4	7							
146							9	8	17	1		1			1	1			
148							1	8	9	4	4	8							
150							3		3	4	1	5	2		1	3			
152							2	7	9	1	3	7	1	1	2				
154								5	5	1	5	9			1	1		1	1
156								5	5	3	7	10	2		2	4			
158								1	1	1	6	7	2		3	5		1	1
160										4	7	8	3		1	1			
162										2	4	6	1		3	4			
164											2	2	2			2			
166											1	1			4	4	1	2	3
168											2	2			2	2	1	3	4
170															2	2			
172															6	6		2	2
174																			
176																		1	1
178																		1	1
Totals	85	111	196	69	95	164	54	76	130	34	50	84	13	27	10	2	11	13	
Average length mm.	84	82	82	117	119	118	137	142	140	150	155	153	158	163	161	167	168	168	

TABLE 6

Average Length at Each Age of the Anchovy in the California Fishery

At end of year	Standard length mm.	Total length mm.	Total length inches
1	92	108	4.3
2	120	142	5.6
3	139	163	6.4
4	152	178	7.0
5	161	188	7.4
6	167	195	7.7
7	171	200	7.9

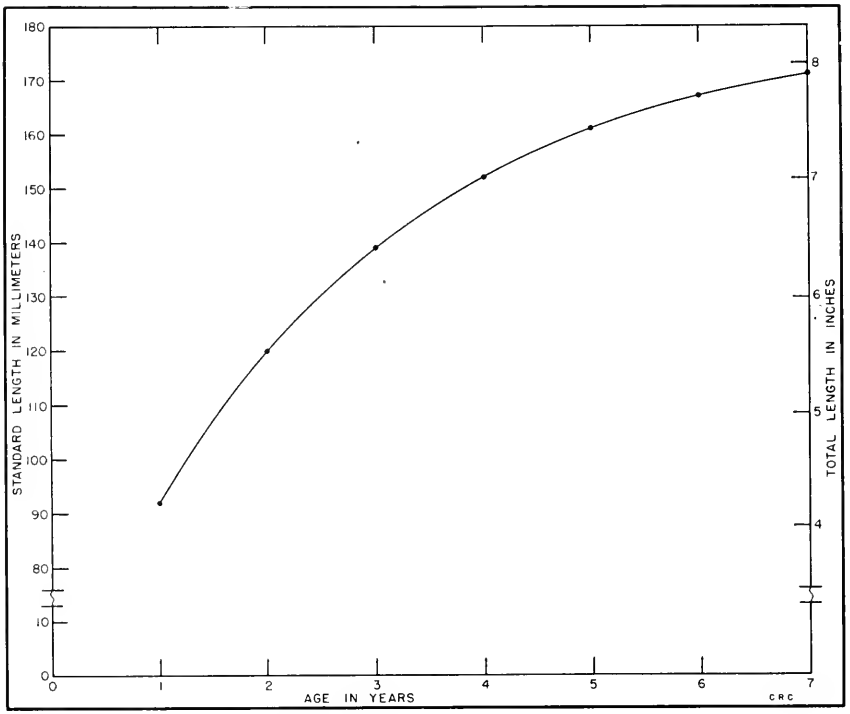

FIGURE 6. Growth curve for the northern anchovy in California

Size at Maturity

Anchovy eggs and larvae have been collected off California at all seasons (Bolin, 1936) and samples of anchovies with developing gonads are taken throughout the year, although there is a somewhat greater proportion in the spring and early summer months. To obtain an estimate of the size at first maturity it was possible, therefore, to use observations on all material collected. No microscopic examinations of the gonads were made and data for females only have been compiled. All females with visible eggs and those definitely spent were included in the maturing category. No significant differences in size at maturity were evident between the Monterey and Southern California anchovies and the data have been combined. The results (Table 7 and Figure 7) indicate that a

TABLE 7

Number of Maturing and Immature Anchovies at Each 2 Mm., Standard Length
Data for Monterey and Southern California Combined

Standard length mm.	Number			Percent maturing
	Immature	Maturing	Total	
88	1		1	0
90	3	1	4	25
92	1		1	0
94	3		3	0
96	6	1	7	14
98	15	3	18	17
100	15		15	0
102	21	4	25	16
104	15	7	22	32
106	26	7	33	21
108	29	13	42	31
110	41	13	54	24
112	40	19	59	32
114	41	19	60	32
116	37	23	60	38
118	38	19	57	33
120	46	26	72	36
122	31	20	51	39
124	30	23	53	43
126	24	15	39	38
128	19	24	43	56
130	23	29	52	56
132	27	31	58	53
134	13	31	44	70
136	16	42	58	72
138	11	43	57	75
140	11	52	63	83
142	14	60	74	81
144	7	69	76	91
146	7	82	89	92
148	3	87	90	97
150	4	107	111	96
152	6	124	130	95
154	5	123	128	96
156	2	112	114	98
158	2	119	121	98
160	3	114	117	97
162	1	108	109	99
164	1	103	104	99
166	1	86	87	99
168		46	46	100
170		37	37	100
172		20	20	100
174		20	20	100
176		14	14	100
178		5	5	100
180		1	1	100
182		2	2	100
184		2	2	100
Totals	642	1,909	2,551	

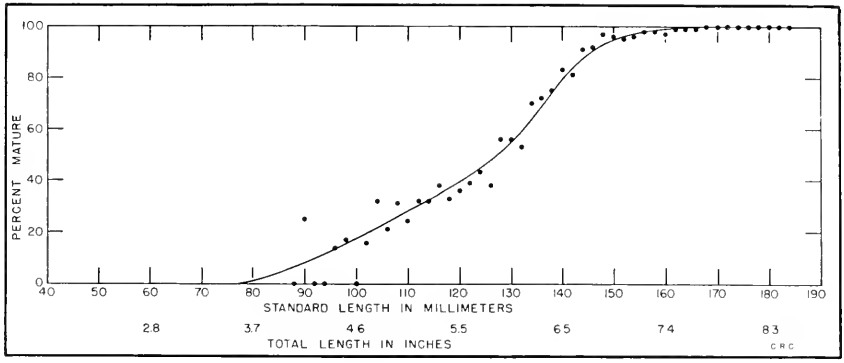

FIGURE 7. Size at maturity of the northern anchovy

few females are maturing at 90-100 mm., standard length, about 30 percent at 100-120 mm., 50 percent at 130 mm., 80 percent at 140 mm., 95 percent at 150 mm. and that practically all larger anchovies are adult. Based on average size at each age (Table 6), these percentages indicate that a few anchovies mature at one to two years, about half are mature at two to three years and all are mature at four years.

SUMMARY

The anchovy fishery in California is concentrated primarily on one species, the northern anchovy, *Engraulis mordax mordax*. This species ranges from British Columbia southward to Southern Baja California.

The bulk of the anchovies taken in Southern California are utilized as bait, either live, ground, salted or frozen. Some canning of anchovies has been done in Southern California, but mostly on an experimental basis. With the failure of the sardine fishery in 1945-46, the processors in Central California commenced canning anchovies on a moderate scale. A small amount of fish in this area is also used as fresh or salted bait.

Straight reduction of whole anchovies into oil and meal is prohibited in California.

Samples of anchovies in the commercial catches in Southern and Central California have been taken since 1946. Frequency polygons for Monterey indicate that anchovies in this fishery ranged from 96 to 184 mm., standard length, 4.4 and 8.5 inches total length, with an average of 148.8 mm., or 6.9 inches, total length. Fish in Southern California were markedly smaller than those taken at Monterey, with a range from 48 to 166 mm., standard length, and an average of 116.4 mm., or 5.3 inches, total length.

The ratio of females to males was 1.4 at Monterey and 1.2 in Southern California.

Total length was calculated by multiplying standard length in millimeters by 1.17111 and converting to inches.

The weight-length relationship of anchovies in the California fishery is expressed by the formula $W = 0.000333L^{3.4074}$. The average length of all fish measured at Monterey would yield 23,000 fish per ton and in Southern California 55,000 fish per ton.

Age and growth of the anchovy were ascertained from scales. The oldest fish in the fishery had completed seven years of life.

The lengths at each age represent a rather wide dispersion and may reflect a protracted spawning period, as well as differences in growth due to different environmental conditions.

A few females mature at 90-100 mm., standard length, or at an age between one and two years. Fifty percent of the females mature at about 130 mm., standard length, or between two and three years. Practically all fish are mature at 150 mm., standard length, or four years and older.

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TWO UNUSUAL RECORDS OF MARINE FISHES AT MONTEREY, CALIFORNIA[1]

By ROLF L. BOLIN
Hopkins Marine Station of Stanford University
Pacific Grove, California

Verrunculus polylepis. Fine-scale Triggerfish.

On June 26, 1951, John Firpo, fishing with hook and line from the old Booth Co. wharf in Monterey Harbor, caught an 11-inch specimen of the fine-scale triggerfish, *Verrunculus polylepis* (Steindachner). Although this particular representative of the typically tropical family Balistidae is an infrequent visitor to Southern California, it has apparently not been taken previously north of Point Conception (Roedel, 1950). The individual caught at Monterey thus represents a northern extension in the known range of the species of well over 200 miles and, what is more important, a penetration of the abrupt temperature gradient in the vicinity of Point Conception, which acts as an effective barrier in limiting the the distribution of so many marine animals. The specimen was purchased from the fisherman and is preserved in the collections of the Hopkins Marine Station.

Since it seems advisable to present morphometric data on specimens which represent the known extremes of ranges, I list here a number of measurements and counts. The measurements are in millimeters and are followed by parenthetic values representing per mille of standard length.

Standard length, 228.0; distance from first dorsal to ventral spine, 130.5 (572); distance from second dorsal to anal, 111.5 (489); depth of caudal peduncle, 18.8 (82); width at pectoral base, 32.0 (145); length of head, 74.2 (321); diameter of membranous orbit, 14.9 (66); interorbital width, 22.5 (99); length of snout, 53.3 (234); length of maxillary, 14.0 (61); length of gill opening, 22.0 (262); predorsal length, 79.1 (347); length of first dorsal base, 37.0 (162); length of first dorsal spine, 43.4 (191); distance from snout to second dorsal, 135.3 (593); length of second dorsal base, 82.9 (36.4); length of longest (third) dorsal ray, 58.1 (255); preanal length, 141.1 (619); length of anal base, 69.8 (306); length of longest (fourth) anal ray, 54.8 (240); length of caudal, 59.5 (262); distance from snout to pectoral, 70.4 (311); width of pectoral base, 15.9 (70); longest pectoral ray, 29.0 (127); distance from snout to ventral spine, 125.8 (552). Fin rays: D. III-27; A. 24; C. 12; P. 14. About 66 scales in longitudinal series from upper end of gill opening to end of hypural.

[1] Submitted for publication November, 1951.

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Pleurogrammus monopterygius. Atka Mackerel (Figure 1)

Less than two weeks after the capture of the triggerfish, an even more surprising visitor, but this time a northern one, was taken off the outer coast of the Monterey Peninsula. This was a 14-inch atka mackerel taken by hook and line from the party boat STAG and kindly presented to the Hopkins Marine Station by Chris Arcoleo, captain of the vessel. The fish, *Pleurogrammus monopterygius* (Pallas), is not a mackerel at all, but a greenling, a member of the family Hexagrammidae. It was caught on July 8, 1951, in about 25 fathoms of water off Bird Rocks, at approximately 36° 36′ N. Latitude, 121° 59′ W. Longitude. The species has long

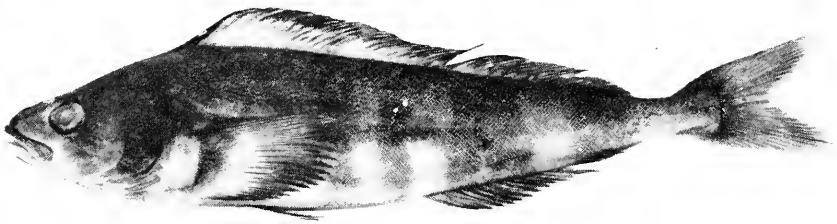

FIGURE 1. Atka mackerel, *Pleurogrammus monopterygius. Photograph by J. B. Phillips.*

been known from the Aleutian Islands and the Bering Sea, where it has been taken on the coast of Kamchatka, at the Kommandorsky Islands and at the Pribilofs. Evermann and Goldsborough (1907, p. 290) report that it has been taken as far east as the Shumagin Islands. All members of the family are comparatively shallow-water fishes limited to shore regions. The Monterey specimen extends the known range of the species for more than 2,500 miles in an arc to the east and south along the coast. The occurrence of the species in central California is, to say the least, astonishing.

Measurements and counts: Standard length, 303.0; distance from dorsal to pelvic, 73.3 (242); depth at anal origin, 51.0 (168); depth of caudal pedunele, 18.0 (59); width at pectoral base, 41.0 (135); length of head, 80.3 (266); diameter of membranous orbit, 15.7 (52); interorbital width, 23.8 (79); length of snout, 14.8 (49); length of maxillary, 29.3 (97); predorsal length, 76.4 (254); length of dorsal base, 197.5 (652); length of longest (seventh) dorsal ray, 34.2 (113); preanal length, 177.3 (585); length of anal base, 74.0 (244); length of longest (sixth) anal ray, 31.6 (104); distance from snout to pectoral, 82.2 (271); width of pectoral base, 27.0 (89); longest pectoral ray, 61.1 (202); distance from snout to pelvic, 103.4 (341); length of pelvic, 45.9 (151). Fin rays: D. 49½; A. 25½; C. 16; P. 25; V. I,5. Scales, 148+22 on the left side, 145+20 on the right. Gill rakers, 6+1+17.

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FOOD HABITS, PRODUCTIVITY AND CONDITION OF THE DOYLE MULE DEER HERD [1]

By ROBERT W. LASSEN, CAROL M. FERREL and HOWARD LEACH
Bureau of Game Conservation
California Department of Fish and Game

The Doyle winter deer range covers an area of about 400 square miles principally in Lassen County, California, and Washoe County, Nevada. It drains a summer range of about 1,200 square miles, most of which is in Plumas County, California.

A program for investigating the mule deer herd which winters on this range was initiated by the California Department of Fish and Game in the fall of 1948. Subsequently, the study became a cooperative venture between representatives of the Nevada Fish and Game Commission, the Bureau of Land Management, the U. S. Forest Service, and the California Department of Fish and Game. This group, the Lassen-Washoe interstate deer study committee, conducts these investigations to obtain data that can be used to formulate a sound management program for the Doyle deer herd and its range.

The Doyle deer herd offers unusual opportunities for study in that each year a generous supply of salvable carcasses is made available through accidents caused by automobiles, trains, entanglement in agricultural fences, malnutrition and unknown causes. Stomach contents, breeding phenomena and data on general physical condition were obtained from 213 mule deer (*Odocoileus h. hemionus*) found on the winter range.

RANGE COMPOSITION AND PAST USE

The present production of range forage for big game and livestock is low. The status of this typical Great Basin winter deer range no doubt results from past abuse by livestock and deer in numbers more than the area could support. Years of heavy use by sheep, cattle and deer have damaged the range by depletion of the better range browses and perennial grasses. At the present time, composition of sagebrush, bitterbrush and annual grasses make up approximately 25 percent of the ground cover. Bitterbrush which makes up little more than 2 percent of the ground cover is the most important available browse and consequently is by far the heaviest cropped shrub species on the winter range.

Table 1 shows the ground cover composition as determined by 208 permanent line-point plots located on the winter range. The depleted condition of the bitterbrush stand is indicated by the survey data presented in Tables 2 and 3. It will be noted that seedlings appear absent, and that only 2 percent of the stand is classified as young plants, while over 55

[1] Submitted for publication January, 1952. Funds for this study were provided in part by the Federal Aid in Wildlife Restoration Act, Project California W25-R.

percent of the stand is rated as decadent. Over three-quarters of the bitterbrush shrubs examined were classified as heavily hedged as a result of continued over-browsing.

The Doyle winter deer range is not damaged beyond repair. However, unless adjustments in numbers of livestock and deer are made so as to bring the stocking into balance with the range carrying capacity, the supply of deer foods will eventually be destroyed. Considerable reductions in livestock use have been made over the past 15 years by the federal agencies responsible for administration of grazing on the government lands within the winter deer range.

TABLE 1

Composition of Ground Cover Doyle Winter Deer Range

Class of cover	Average percentage of ground cover	Class of cover	Average percentage of ground cover
Annual grasses	9.5	Blue grass	0.1
Annual weeds	1.0	Miscellaneous grasses, forbs and shrubs	0.5
Total annuals	10.5	Total perennials	20.5
Sagebrush	12.0	Total vegetation cover	31.0
Bitterbrush	2.2		
Desert peach	1.6	Bare ground (including rock)	32.1
Rabbitbrush	1.5	Litter	30.2
Horsebrush	1.2	Dead sagebrush	3.5
Juniper	0.7	Dead bitterbrush	0.7
Wild currant	0.3	Dead rabbitbrush	1.2
Hop sage	0.1	Dead desert peach	0.7
Desert tea	0.1	Dead miscellaneous shrubs	0.6
Needle grass	0.1	Total nonproductive	69.0
Squirrel-tail grass	0.1	Grand total	100.0

TABLE 2

Age Classes of Bitterbrush

Class	Percentage of stand	Class	Percentage of stand
Seedlings	0.0	Mature shrubs	42.6
Young shrubs	2.0	Decadent shrubs	55.4

TABLE 3

Form Classes of Bitterbrush

Class	Percentage of stand	Class	Percentage of stand
All available, little or no hedging	0.5	Partly available, little or no hedging	1.0
All available, moderately hedged	17.3	Partly available, moderately hedged	4.6
All available, heavily hedged	72.5	Partly available, heavily hedged	4.1

FIGURE 1. Deer browse line on juniper trees.
Photo by U. S. Forest Service.

FIGURE 2. Bitterbrush shrub showing results of heavy use

WHAT DEER EAT

The examination of deer stomachs yields valuable information on what deer eat and when they eat it. Collection of deer stomachs from the Doyle winter range was started in the fall of 1948 and has continued through 1951. Of the 206 stomachs examined, 186 were taken from road kills. In

TABLE 4

Volume Percent Summary of the Main Food Items Consumed by Doyle Winter Range Deer [1]

	Number specimens 206	Oct.	Nov.	Dec.	Jan.	February			March			April		
		11	11	10	8	8 1949	16 1950	13 1951	19 1949	30 1950	15 1951	20 1949	23 1950	11 1951
Browses														
Juniperus occidentalis	Sierra Juniper	----	----	3.5	----	tr.	2.3	tr.	0.1	1.2	tr.	0.9	tr.	----
Pinus ponderosa	Yellow Pine	tr.	tr.	tr.	tr.	13.1	tr.	10.0	1.1	0.7	3.6	5.8	tr.	0.1
Salix spp.	Willows	1.4	18.5	----	tr.	----	2.8	----	0.1	tr.	tr.	tr.	----	tr.
Quercus kelloggii	Black Oak	8.9	5.4	tr.	0.6	tr.	0.6	0.4	tr.	0.9	tr.	0.1	tr.	tr.
Cercocarpus ledifolius	Desert Mahogany	tr.	tr.	5.3	----	tr.	0.4	----	tr.	----	tr.	tr.	----	1.8
Prunus andersonii	Desert Peach	----	2.5	tr.	----	----	----	tr.	tr.	----	----	tr.	0.3	50.5
Purshia tridentata	Bitterbrush	48.8	13.0	18.4	9.6	1.9	2.3	tr.	1.1	0.6	tr.	0.3	3.9	17.5
Rosa californica	Wild Rose	10.5	0.2	----	----	----	tr.	----	----	----	----	----	----	13.3
Ceanothus prostratus	Mahala Mat	tr.	7.7	5.4	----	----	1.8	1.5	----	1.0	1.7	1.5	2.0	3.7
Ceanothus velutinus	Tobacco Brush	3.1	2.5	2.6	0.6	----	0.6	----	----	0.7	----	3.5	2.9	0.6
Arctostaphylos patula	Green Manzanita	----	tr.	1.2	----	----	----	1.2	----	----	tr.	----	0.1	tr.
Artemisia tridentata	Common Sagebrush	tr.	16.9	14.7	68.1	70.0	57.2	39.6	59.9	41.7	38.7	31.2	42.9	6.6
Miscellaneous browses		5.5	2.5	tr.	tr.	tr.	1.5	tr.	1.6	1.2	3.0	0.1	0.5	tr.
Total browses		78.2	69.2	51.1	78.9	85.0	69.5	52.7	63.9	48.0	47.0	43.4	52.6	94.1
Forbs														
Medicago sativa	Alfalfa	10.7	1.4	5.5	----	tr.	10.3	0.4	17.5	5.6	6.5	tr.	14.3	tr.
Miscellaneous forbs		11.0	4.2	2.8	1.3	10.7	3.7	2.1	3.4	0.8	5.3	0.6	2.3	0.9
Total forbs		21.7	5.6	8.3	1.3	10.7	14.0	2.5	20.9	6.4	11.8	0.6	16.6	0.9
Gramineae														
Dry grass		tr.	16.6	6.9	18.2	4.0	9.8	7.4	13.9	19.5	0.7	13.0	7.4	tr.
Green grass		0.1	8.6	33.7	1.6	0.3	6.7	37.4	1.3	26.1	40.5	43.0	23.4	5.0
Total grasses		0.1	25.2	40.6	19.8	4.3	16.5	44.8	15.2	45.6	41.2	56.0	30.8	5.0

[1] Those food items amounting to 1.0% or more by volume.

1951 the California Fish and Game Commission and the Nevada Game Commission authorized the monthly collection of additional deer by shooting for disease and food habits study. Twenty stomachs were taken on the winter range by this permit, 15 from Washoe County, Nevada, and five from Lassen County, California.

A summary of the result of the deer stomach analysis is presented in Table 4. Because only few deer were collected during October through

TABLE 5

Supplemental List of Plants Found in the Stomachs of Deer Collected From the Doyle-Washoe Range [1]

Bryophyta	Moss	Berberis sp.	Barberry
Equisetum sp.	Horsetail	Lepidium sp.	Pepper-grass
Abies concolor	White Fir	Sisymbrium altissimum	Tumbling Mustard
Libocedrus decurrens	Incense Cedar	Thysanocarpus sp.	Fringe-pod
Ephedra viridis	Mexican Tea	Ribes velutinum	Gooseberry
Cyperaceae	Sedge Family	Amelanchier alnifolia	Western Service Berry
Carex sp.	Sedge	Prunus demissa	Western Choke-cherry
Juncus sp.	Rush	Astragalus sp.	Rattle-weed
Liliaceae	Lily Family	Lupinus sp.	Lupines
Populus sp.	Poplar	Robinia sp.	Locust
Quercus kelloggii	California Black Oak	Lomatium sp.	Hog-fennel
Phoradendron sp.	Mistletoe	Umbelliferae	Parsley Family
Polygonum aviculare	Wire grass	Phlox gracilis	Phlox
Rumex sp.	Dock	Polemoniaceae	Gilia Family
Eriogonum sp.	Buckwheat	Amsinckia sp.	Amsinckia
Sarcobatus vermiculatus	Black Greasewood	Symphoricarpus albus	Snow Berry
Salsola kali	Russian Thistle	Chrysothamnus nauseosus	Rabbit Brush
Montia perfoliata	Indian Lettuce	Chrysothamnus viscidiflorus	Rabbit Brush
Paeonia brownii	Western Peony		

[1] Those food items amounting to 1.0% or more by volume.

January, it appears best to combine the data collected during the three winters for these months. From February through April the data are summarized by separate winters.

A generalized graphic representation of the deer food habits is presented in Figures 3 and 4.

Use of Browses

Bitterbrush (*Purshia tridentata*) and big sagebrush (*Artemisia tridentata*) are the two browse species most abundant on this winter range. They are considered to be staple foods in the diet of this herd. Of the two, bitterbrush is considered the key browse species. Use of bitterbrush is greatest in October when the deer first come on to the winter range where it averages 48.8 percent of the contents of stomachs examined. From November through January the percentage of bitterbrush varies from 18.4 percent to 9.6 percent of the diet. The low point of use occurs in February and March when the highest percent in the stomachs was 2.3. Normally in April the consumption of this plant is low, but in 1951 a marked increase in use occurred in April due probably to the unusually early appearance of new growth resulting from mild weather.

Sagebrush appears as the principal browse found in the deer stomachs. The heaviest use of sagebrush is indicated from January through April when it averages from 6.6 percent to 70 percent. In October a trace was

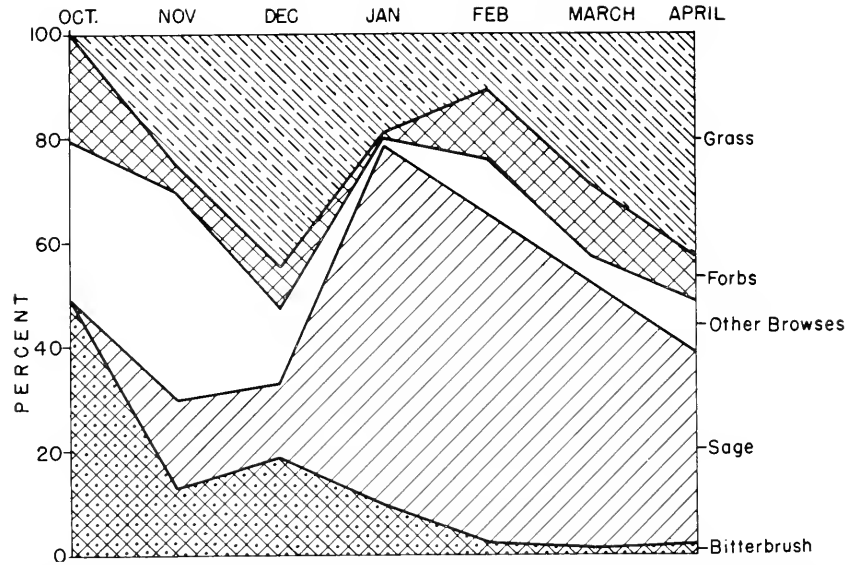

FIGURE 3. Graphic representation of the diet of Doyle deer the winters of 1949 and 1950 (cold-dry). Note: Months October through January include data from the three winters studied.

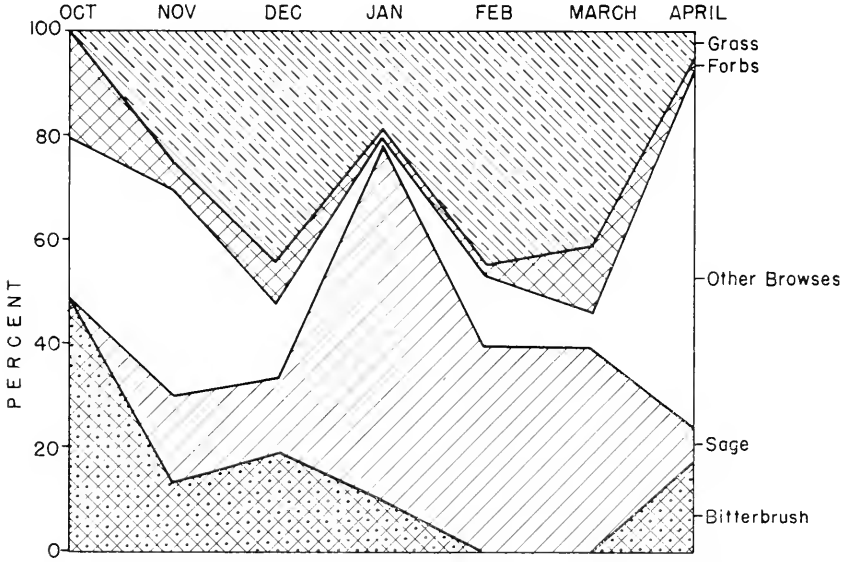

FIGURE 4. Graphic representation of the diet of Doyle deer the winter of 1951 (mild-moist). Note: Months October through January include data from the three winters studied.

found. It should be noted that in April, 1951, the use of sagebrush appears as markedly less than in 1949 and 1950. When the new growth of other browse species became available, the deer consumed less sagebrush.

The pattern of use of bitterbrush and sagebrush is graphically illustrated in Figures 3 and 4. A similar pattern was noted in stomach analysis data on the Devils Garden interstate deer herd in Modoc County,

California (Interstate Deer Herd Committee, 1951). On the Devils Garden area a shift from bitterbrush to sagebrush occurred in late winter even though some bitterbrush was still available. On the Doyle-Washoe range the seasonal growth of bitterbrush is virtually all utilized by midwinter with the result that the level of use of this plant after October is perhaps lower than would be expected on a more healthy range. Bitterbrush seems to have a period of low palatability in February, March and April.

Several other browse plants are present on the Doyle-Washoe area but none of them are sufficiently abundant to be considered a staple food plant on the area. In the more elevated parts of the range which are only available to the deer during periods of light snow, are found mahala mat (*Ceanothus prostratus*), tobacco brush (*Ceanothus velutinus*), and green manzanita (*Arctostaphylos patula*). Willows (*Salix* spp.), wild rose (*Rosa californica*), and desert peach (*Prunus andersonii*) are found at lower elevations but are deciduous and appear to be used only in the fall and spring. Heavy use of the new growth of wild rose and desert peach was indicated in April 1951 when the mild spring brought about an unseasonable growth of these plants. Desert mahogany (*Cercocarpus ledifolius*), which is considered a desirable browse on most mule deer ranges, is present only as mature highlined plants. Common browse plants on this range which showed up only in trace amounts in the stomachs were rabbit brush (*Chrysothamnus* spp.) and horse brush (*Tetradymia* sp.).

Use of Forbs

Forbs occurred in the stomachs in varying amounts throughout the winter decreasing from 21.7 to 0.6 percent of the diet. The most important single species taken was alfalfa (*Medicago sativa*). Alfalfa made up 17.5 percent of the contents of 19 stomachs taken in March 1949 which was the greatest use of the plant noted. Consumption of alfalfa on this range represents depredation on the fields of local ranchers. This depredation on alfalfa is more intensified during severe winters. Other important forbs taken were filaree (*Erodium* spp.), poverty weed (*Iva axillaris*), dock (*Rumex* spp.), tumbling mustard (*Sisymbrium altissimum*), and phlox (*Phlox* spp.).

Use of Grass

Grass is of special importance to the deer on this range because of the poor condition of browse species present. The dominant grass on the winter range is cheat grass (*Bromus tectorum*) and most of the grass observed in the stomachs was probably of that species.

Grass was important in all months except October making up 4.3 percent to 56.0 percent of the diet from November through April. The amount of green grass in the diet was notably higher in February and March of 1951 than it was during the winters of 1949 and 1950. The winter loss of deer in 1951 was less than the severe die-offs in 1949 and 1950. It is thought that the increase in green feed, notably grass, on the range during the mild open winter of 1951 was one of the factors responsible for better survival. It is noteworthy that consumption of green grass in April 1951 fell to 5.0 percent when the new growth of browses became available to the deer.

PRODUCTIVITY

Coincident with the establishment of the Dixie Mountain refuge, and under the protection of a "buck law," the population of mule deer on the Doyle range increased. The protection afforded this herd resulted in an inevitable population complex, with too many animals on a deteriorating range. Inadequate cover and poor quality foods have contributed to the poor production and extremely low fawn survival indicated by this study.

FIGURE 5. Mule deer embryo, 144 days (12-inch ruler)

FIGURE 6. Embryonic development during the winter range period

Fetal examinations were made of all pregnant does. Embryos ranging in age from approximately three weeks to five months were large enough to sex (Chattin 1948) and to determine their respective ages. Thus the dates of conception were established and the breeding period determined. The breeding dates of 72 of the pregnant does examined were plotted. The data compared very closely with the dates of Chattin's study of the Devils Garden interstate deer herd, as shown in Figure 7. If 85 percent

TABLE 6

Pregnancy Data

Year	Number does examined	Number pregnant	Percent pregnant	Number embryos per pregnant doe	Number embryos per doe
1948-49	39	36	92	1.50	1.38
1949-50	33	26	78	1.34	1.06
1950-51	17	14	82	1.50	1.23
1948-51	89	76	85	1.44	1.23

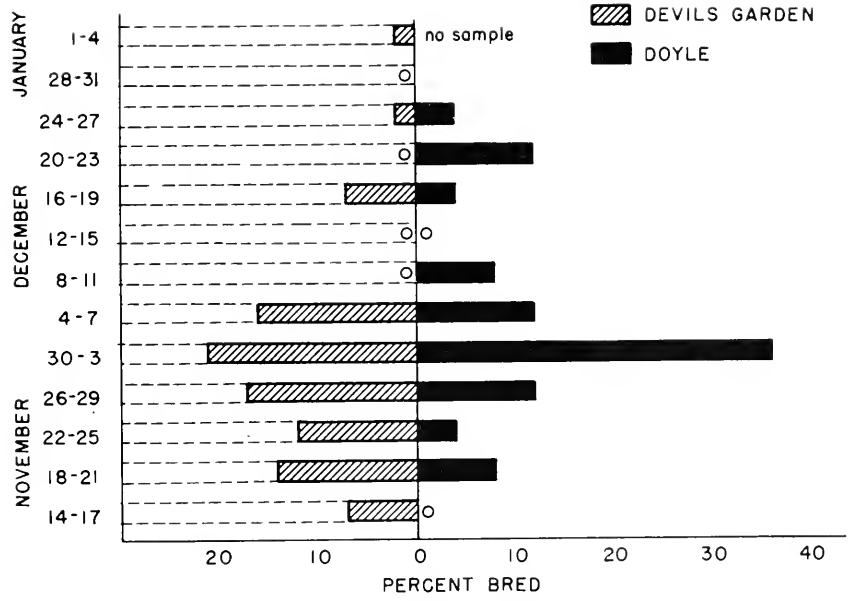

FIGURE 7. Breeding season of two mule deer herds in California based on embryo development

of the does, including yearlings, are bred and 60 percent of this breeding is accomplished during a 12-day period from November 26th to December 7th, then apparently the ratio of breeding bucks to breeding does is adequate. If does fail to become pregnant during the three estrus periods (probably 60 days) the chances are they were not physically capable of conception.

Sex determination of 106 embryos reveals a buck :doe ratio of 107 :100.

An examination of ovicular material from the female deer revealed that mature does (age over 30 months) show 1.4 corpora lutea scars

per doe. Ovaries of the fawns and yearling does examined showed no indications of follicular maturity. When adequately nourished, a large percentage of the yearling class deer will mature and breed, dropping their fawns the following spring. Morton and Cheatum (1946) reported as high as 39 percent of the fawns on good range in New York State breeding the first year, while on the less adequate range, less than four percent of the fawns were found pregnant. On the Doyle range, however, none of the fawns examined have been pregnant, and the ova production of the yearling and older does has been below the average for other herds examined in California.

An analysis of Table 7 (herd composition and age counts) reveals an extremely low percentage of yearling class deer in the Doyle herd. Careful herd composition and age counts were made during the 1948 and 1949

TABLE 7

Herd Composition and Age Counts, 1949 and 1950

Method	Number	Percent			
		Bucks	Does	Yearlings[1]	Fawns
Carcasses	213	14	48	6	32
Fall herd composition counts	1539	8	52	6	34
Average	1752	9	51	6	34
Normal		10	35	20	35

[1] Includes both sexes.

post hunting and rutting season. No attempt was made at that time to segregate yearling does, but antlered deer were recorded in antler classes. Spiked deer were classed as yearling animals. During the early part of the 1950 rutting period, the smaller class of bucks were aged by antler size and development. For the purpose of discussion, an assumption is made that all the spiked bucks counted were yearlings and that an equal percentage of the deer herd consisted of yearling does. The percentage of yearlings in the herd so computed was 6 percent.

The highway-killed deer, and other deer carcasses salvaged on the winter range, were aged by the dentition classification described by Hunter (1947). Here again the percentage of yearlings was very low and, like the fall herd composition counts, made up only 6 percent of the herd.

It is generally considered by those working with Rocky Mountain mule deer in California that a normal herd should include 20 percent yearlings. The data presented above indicates the production of the Doyle herd is extremely low.

HERD CONDITION

The initial general survey of the Doyle range suggested the possibility that the deer were suffering from nutritional poverty. The recognition of malnutrition is an important step toward the eventual correction of this problem. During examination of all deer carcasses, symptoms of

malnutrition were recorded. The symptoms looked for were those suggested by Harris (1945) and included an examination of the bone marrow to determine the degree of absorption of the fat cells.

Under the conditions present on the Doyle range during the months of January, February and March the stored fat deposits of the deer disappeared and emaciation became apparent. Generally the deer were regarded as in fair condition during January. By February some evidence of fat absorption was apparent and by March and April the deer exhibited signs of advanced malnutrition. During March and April 1950, 30 percent of the deer examined showed signs of advanced nutritional deficiency.

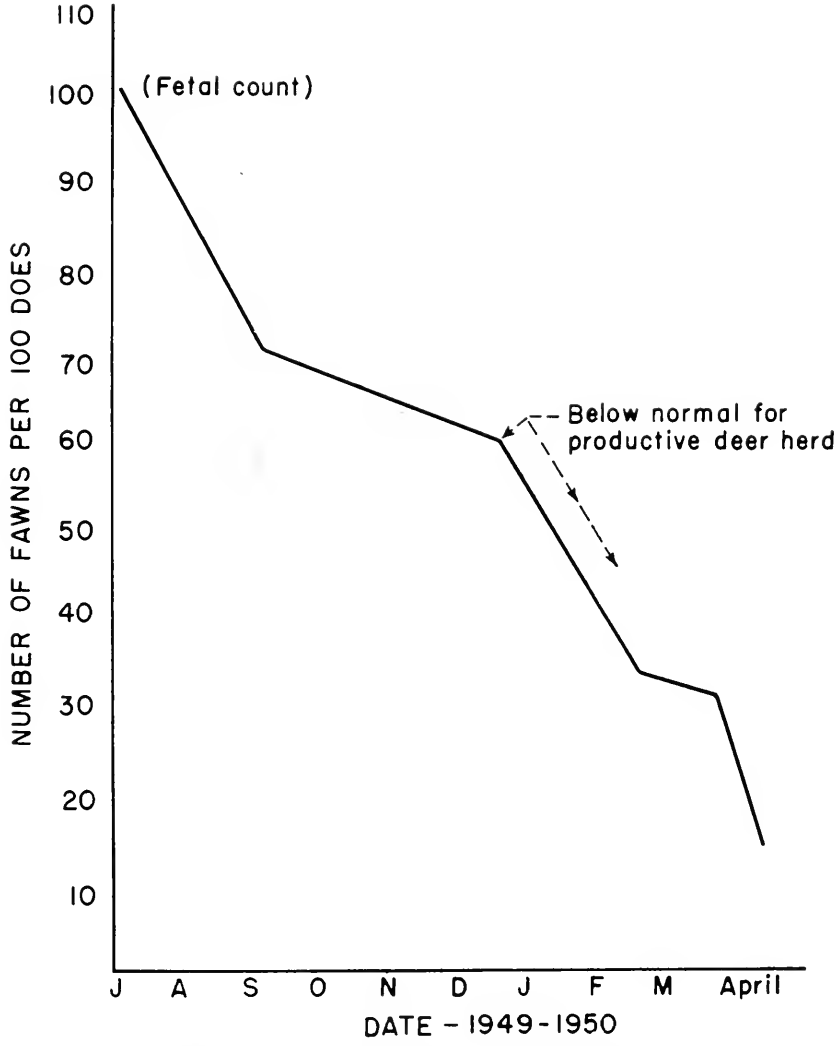

FIGURE 8. Fawn survival as taken from herd composition counts

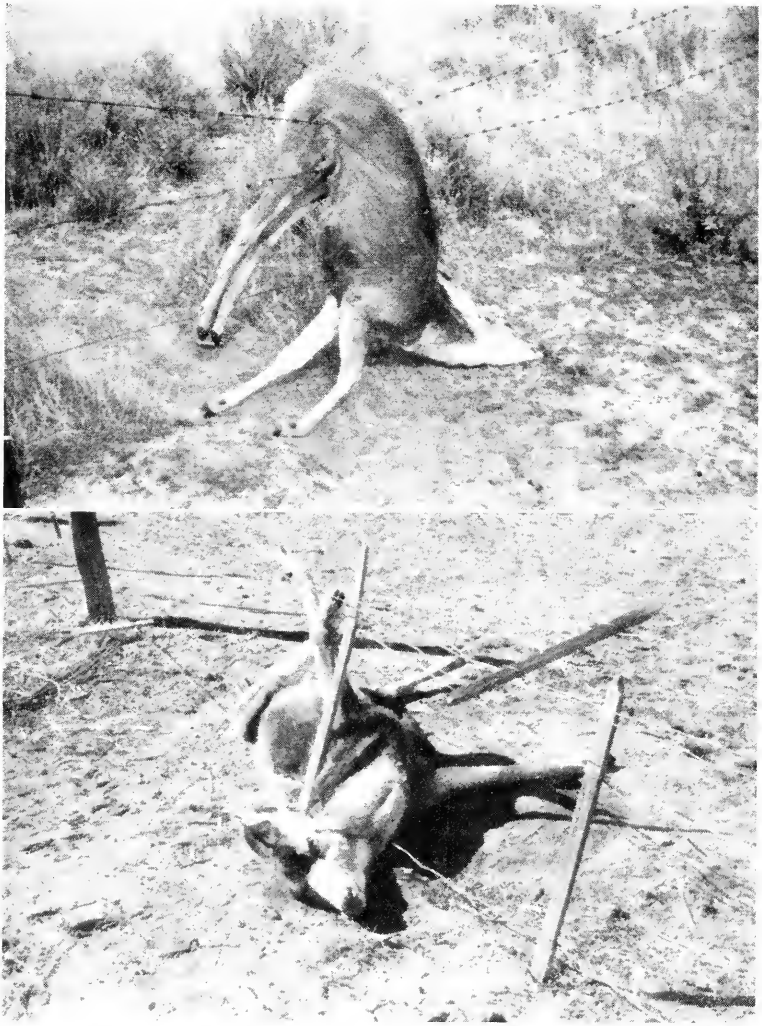

FIGURE 9. During February, March and April deer in poor condition fail to jump over agricultural fences which are only 40 to 50 inches high

The apparent deficiencies became serious with fawns during early 1950, as shown in Figure 8. Herd composition work was carried on throughout the winter and early spring period. By the time the deer left for the summer range 82 percent of the fawns wintering on the range had died from malnutrition, accidents, and other causes. The low survival of fawns, represented by a doe : fawn ratio of 100 :12 at 11 months of age, obviously accounts for the alarming 6 percent yearling composition.

The question has been raised as to whether or not doe : fawn ratios can be successfully taken during the entire winter range period. The observer was fortunate enough to be in the field several days of each

week from November 1949 through April 1950 and was able to continue to separate the deer of the year from the older deer. By assuming that the fall herd composition ratios remained constant for older animals throughout the winter, it was possible to use fawn : adult ratios to work out the doe : fawn ratio of 100 :12.

TABLE 8

Girth Measurements in Inches, 1949-50

	October-December		January-February		March-April	
	Number measured	Girth	Number measured	Girth	Number measured	Girth
Fawn	12	26.5	9	27	20	25
Doe	11	35	5	35	23	32
Buck	2	35	3	37	7	36

An examination of Table 8 (girth measurements) reveals that during the winter range period of 1949-50 weight losses were excessive. Weights of deer taken during the hunting season at several U. S. Forest Service checking stations show the deer to be in good condition with some adult bucks weighing over 200 pounds. Field observations during the summer range period find deer of all age classes active and thrifty looking. Apparently the deer gain weight while on the summer range but lose these gains later on.

The appearance of deer suffering from extreme malnutrition is striking. It is not hard to recognize their prominent emaciated features and notice their lack of energy. Generally the herd loses its energy during late winter and early spring and individuals frequently get caught in agricultural fences during this period. Deer which exist under unfavorable nutritional conditions are subject to many decimating factors in addition to direct starvation. Generations of animals living under such conditions are bound to become smaller, slower, less able to resist diseases and parasites, than are deer on thrifty, productive, well managed range lands.

SUMMARY

High-lining and hedging of the better forage species on the Doyle winter deer range are indications that the quality and quantity of available food is not good.

Stomach analysis of 206 deer, of which 186 were taken from road kills, indicate that sagebrush was the principal browse. Bitterbrush is the second most abundant browse plant on the Doyle winter range and is considered a staple item in the diet of this herd. The bitterbrush stand is overcropped and in a depleted condition. Several other browse plants are present on the range but none of them are sufficiently abundant and/or palatable to be considered important.

Of the forb plants present in the deer stomachs, alfalfa was the most important single species taken. Alfalfa made up 17.5 percent of the contents of the stomachs taken during March 1949. This represents an important depredation problem to local ranchers.

Cheat grass is the dominant grass plant on the range and is the most important supplement to the browse species present. During mild winters the early availability of this green feed is likely an important contributing factor to better survival.

Poor survival of fawns and yearling deer account for the low productivity of the herd. Malnutrition and winter kill probably accounts for the biggest share of the losses. The data indicate that during the winter range period of 1949-50, 82 percent of the fawns died.

Good quality forage on good range will maintain a deer herd during the winter period and keep the animals healthy and productive. On the Doyle range, dead deer in an emaciated condition were found with stomachs full of annual grass and sagebrush, indicating these foods may not have the nutritive value needed to sustain deer. Under the conditions now prevailing, deer of the Doyle herd are losing body weight, health, and productivity.

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METHODS FOR ESTIMATING DEER POPULATIONS FROM KILL DATA[1]

By RAYMOND F. DASMANN
Museum of Vertebrate Zoology
University of California, Berkeley

An accurate inventory of a big game population may require much time and expense. With a numerous and widespread species such as deer, a census is particularly difficult. As a result, many states have turned away from efforts to census deer, and now base management plans on trend counts. In other states the deer populations are estimated from kill data by use of various methods.

In California during a recent survey of deer herds and ranges (Longhurst *et al.*, 1952) a study was made of methods of estimating deer populations from the kill. This paper attempts to analyze some of the problems involved, and to present conclusions on the relative utility of various ways of calculating deer numbers.

In the preparation of this report the writer received much valuable assistance from A. Starker Leopold of the Museum of Vertebrate Zoology. Helpful suggestions also were contributed by William Longhurst and Richard Taber of the same institution, Ian McTaggart Cowan of the University of British Columbia, and William P. Dasmann of the California Department of Fish and Game. This aid has been greatly appreciated.

Estimates of animal populations based on kill fall into two general classes. The better of these makes use of kill figures in combination with sex and age ratios. If the necessary data are accurately obtained this method can be exact. The second and older method consists of estimates based on the kill alone, and it is not expected to be accurate. The latter type was used by Seton (1929) to determine animal populations from the known annual mortality. Leopold (1933) developed a similar method as a basis for estimating deer numbers in New Mexico. Such estimates assume that it takes a certain minimum number of animals to sustain any given level of mortality. This fact, while obvious, becomes subject to argument when an attempt is made to define the minimum number.

ESTIMATES BASED ON DEER KILL COMBINED WITH SEX AND AGE RATIOS

Formulas for determining animal populations, using the kill in combination with sex and age ratios, are presented by Kelker (1940, 1943) and Petrides (1949). These or similar formulas have been applied to field problems by Rasmussen (1943), Riordan (1948), and Robinette

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(1949). Lauckhart (1950) reports on a simplified method of estimating deer numbers from winter sex and age ratios in combination with the kill.

The idea behind all these methods is as follows: A given herd may have a sex ratio of 50 bucks per 100 does before the hunting season and 30 per 100 after hunting. If the number of bucks removed by hunting is known, the size of the herd can be computed from the shift in sex ratio induced by the hunt. Thus in the above example, 20 bucks were killed for every 100 does in the herd, or one for every five. The total kill multiplied by five should give the number of does in the herd, and the surviving numbers of bucks can be computed from the postseason sex ratio of 30 per 100.

Such calculations of populations from changes in sex and age ratios assume that these changes are brought about by the hunting kill, or other known losses, during the period between two dates when the ratios are determined by field counts. They carry the further assumption that natural losses during the period affect the different sex and age classes in an equal proportion. Thus the timing of the classification counts becomes of primary importance. The specific methods cited above, with the exception of that described by Lauckhart, call for sex and age ratio counts to be made immediately preceding and following the hunting season, which minimizes the effect of natural losses causing changes in the sex ratio. It thus can safely be assumed that the shift in sex ratio resulted almost entirely from the hunting kill.

The chief limitation on the use of these methods is the difficulty of obtaining the necessary data. In particular, the pre-hunting season count has been difficult. In both migratory and resident deer populations, the animals are scattered over large areas at the start of the hunting season. Efforts in California to obtain accurate pre-hunting season ratios for large deer populations have been generally unsuccessful.

The method of estimating presented by Lauckhart avoids the difficulties of a pre-hunting season count by basing the estimates on winter sex and age ratios alone. These ratios are obtained during the winter preceding, and that following the hunting season. In effect the pre-hunting season count is taken eight or nine months in advance. The assumption is that natural losses during this period have affected both sexes in equal proportion.

SOURCES OF ERROR IN ESTIMATES BASED ON KILL AND SEX RATIO DATA

The possibilities of error in population estimates based on deer kill and sex ratio changes should be fully understood. One of the first essentials for estimating numbers in this manner is that the sex and age ratios apply to precisely the same population from which the hunting kill is removed. This obvious requirement is a major obstacle to the use of such methods in many areas. Among migratory herds, sex and age ratio counts are most easily carried out on the winter ranges. The kill takes place in most cases on the summer ranges. While winter range boundaries may readily be defined, the limits of summer ranges are more difficult to determine. During the Jawbone herd study in California, the extent of the summer range used by the deer wintering on Jawbone Ridge was determined by use of tagged deer, and by following actual migration routes (Leopold, *et al,*

1951). Despite three years of study in this area it was not possible to rule out the possibility of overlap between the summer ranges of Jawbone deer and other adjoining herds. As a result it cannot be stated definitely that all of the deer killed from the Jawbone summer range actually were taken from the Jawbone herd. Similar conditions have been noted in many other areas of California.

One way to avoid the necessity of defining exact herd boundaries is to work with areas large enough to minimize the effect of overlap around the edges. This, however, increases the difficulty of obtaining accurate counts of sex and age ratios where large or diversified populations are involved. It is easiest to classify small or homogeneous populations.

The usefulness of the sex ratio methods of estimating deer numbers is further restricted by the necessity for a high degree of accuracy in both kill data and herd classification counts. The difficulty of obtaining accurate kill figures has long been known, and in California data of reasonable accuracy are not yet available. Accurate sex and age ratios are equally difficult to determine. Small errors in determining the sex ratio may be magnified many times when this ratio is used to compute total numbers. Such magnification is most marked in lightly hunted herds where the sex ratio approaches unity (Table 2).

All of the foregoing requirements are equally essential regardless of what mathematical device for estimating numbers finally is used. Additional sources of error are introduced when the sex and age ratio counts are made several months preceding or following the hunting season. The influence of these errors may be demonstrated by applying a method of estimating similar to that of Lauckhart, to the data from the Clavey unit of the Jawbone deer herd.

In the winter of 1948-49 the ratio of bucks:does:fawns in the Clavey area was 36:100:77. The reported hunting kill in 1949 was 246 bucks. In the winter of 1949-50 the ratio of bucks:does:fawns was 36:100:82. In Table 1 we assume that there were an equal number of male and female

TABLE 1

Calculation of Clavey River Deer Population From Kill and Winter Sex Ratios

Season	Bucks	Does	Fawns
Winter, 1948–49	36	100	77
Summer, 1949 (Fawns added to adult totals)	38	39	----------
Prehunting ratio, 1949	74	139	Unknown
Hunting loss in bucks to yield known winter ratio of 36:100	24	----------	----------
Winter, 1949–50	50	139 (Ratio 36:100:82)	114
Surviving population equals sum of last line, or 303 deer.			
Ratio of kill to population is 24/303 or 1/12.6.			
Known kill=246. Calculated population: 246x12.6=3,100.			

fawns, and that natural losses affected both sexes in equal proportion. On this basis, the population is computed to total about 3,100 deer.

No census was carried out in this area during the winter of 1949-50. In 1948-49, however, a pellet group census indicated a population of 4,305. When the known winter losses are subtracted from this, and we consider a probable summer gain in fawns, the population as estimated in Table 1 appears to be reasonably accurate for that period.

The assumptions made in Table 1 must be carefully examined. These are: (1) Fawns survive to yearling age in an approximately equal sex ratio; (2) fawn losses during the winter are proportionately equal to adult losses; (3) losses in adults and yearlings affect both sexes in equal proportion, except for losses due to hunting; and (4) no changes in the sex ratio are introduced by deer movements into or out of the area. Insufficient data are available from the Clavey unit for us to ascertain the validity of most of the above premises. However, the known winter losses during the winter of 1948-49 did not affect fawns and adults in equal proportion. In fact, the ratio of fawns per 100 adult does changed from 77:100 in the winter to about 28:100 the following summer. Therefore, instead of an increment of 77 fawns to the adult population in the summer of 1949, as shown in Table 1, there were only 28 fawns added. The prehunting season sex ratio becomes 50 bucks to 114 does, and the kill necessary to change this to a ratio of 36:100 becomes 9 bucks. The ratio of kill to surviving population thus becomes 1 to 28 instead of 1 to 12.6, and the calculated population, 6,900 deer.

A difference in population estimate from 3,100 deer to 6,900 deer is introduced by a change in only one factor, the winter loss, which normally operates after the winter sex and age ratios are determined. It therefore seems inadvisable to rely upon this method for censusing deer herds that are likely to suffer heavy winter-kill. This has been further demonstrated in Utah by Robinette (1949).

Each of the other premises mentioned in relation to Table 1 contains an additional possible source of error. For instance, it cannot always safely be assumed that fawns will survive in an equal sex ratio. There may be an inequality in sex ratio at birth, as noted by Chattin (1948) who determined an embryo sex ratio of 117 males per 100 females in the Interstate Deer Herd of Modoc County. Robinette and Gashwiler (1950) reported an embryo sex ratio of 126 males per 100 females in Utah. There may also be a differential sex mortality in fawns. Thus Trippensee (1948) quotes Gerstell that in Pennsylvania female fawns outnumbered male fawns in a two to one ratio, the disparity increasing on overbrowsed ranges. Taber (1951) also found a differential sex loss among fawns in Lake County, California.

Losses in yearling and adult deer likewise may not affect both sexes in equal proportion. In Yellowstone, Murie (1940) reports that there were approximately two does for every buck despite the absence of hunting. Cronemiller and Bartholemew (1950) report ratios ranging from 41 to 61 bucks per 100 does in a lightly hunted area of the Angeles National Forest. In Sequoia National Park, counts in an unhunted herd indicated a ratio of about 70 bucks per 100 does. In Canada, unhunted mule deer populations in national parks showed a ratio of 53 bucks per 100 does (Cowan, 1950). These data indicate that the cumulative effects of natural

losses among deer seem to operate differentially against bucks, which would result in underestimating deer populations where only winter sex and age ratios and kill data were available.

Dispersal movements of deer into and out of a population area may have additional effects on population estimates. As yet the data on deer dispersal are not sufficient to evaluate the magnitude of such effects.

USEFULNESS OF ESTIMATES BASED ON KILL DATA AND SEX RATIO CHANGES

In view of the many sources of error involved in estimates based on deer kill and sex ratio counts, it may be questioned whether such estimates have any management value. However, management will always be faced with the necessity of making population estimates. A good guess must be rated higher than none at all. If estimates are guided by deer kill and sex ratio changes they will be better than estimates made without such evidence. The accuracy will vary with the quantity and quality of field data available.

As a necessary basis for any accurate estimate using the above methods, the population boundaries and extent of overlap between adjoining populations must be known. There must be a reasonably accurate determination of the deer kill, including illegal kill and crippling loss. There must be an accurate determination of the sex and age composition of the population. These three categories of information are essential.

A high degree of accuracy can be obtained by making a careful sex ratio count immediately before and just after the hunt and applying these data, plus the determined kill, to the Kelker or Petrides type of formula. The accuracy of the estimate probably will decrease as the time lapse between the sex ratio count and the hunting season increases. With migratory deer it may be necessary to confine classification counts to the winter range. In this case, accuracy may be sacrificed. It would be desirable, where possible, to make one classification count immediately after the deer reach the winter range (the posthunting count), and a second count just before the deer leave the winter range in the spring (the prehunting count). In this second count the extent to which winter losses affect sex and age ratios may be determined, and the error introduced by disproportionate sex losses reduced. According to I. McT. Cowan this spring count has been a standard practice in British Columbia.

Where only one winter classification count is possible the Lauckhart type of method may be used. The sources of error examined above indicate that this method will tend to err on the side of underestimating the population, because the net effect of natural losses causes a reduction in the number of bucks.

ROUGH METHODS OF ESTIMATING DEER NUMBERS

The type of data required for precise determination of deer populations probably will not be available for most deer herds in California in the foreseeable future. Exact herd classification and kill data require time and manpower that may only be available for the most important deer management areas. The same effort often might better be used for a direct census. For other areas, approximations may be necessary.

At the present time, kill figures are available for all California deer ranges. These figures are based on deer tag returns and have been shown to be well below the actual total kill (Hjersman, 1951). Refinement of methods for determining the deer kill may in the future provide more accurate data. These data may be used in estimating populations in areas not being intensively managed.

Estimates using deer kill alone necessarily involve a wider range of premises than those combined with sex and age ratios. The possibility of error increases proportionately. It is possible, however, to determine a

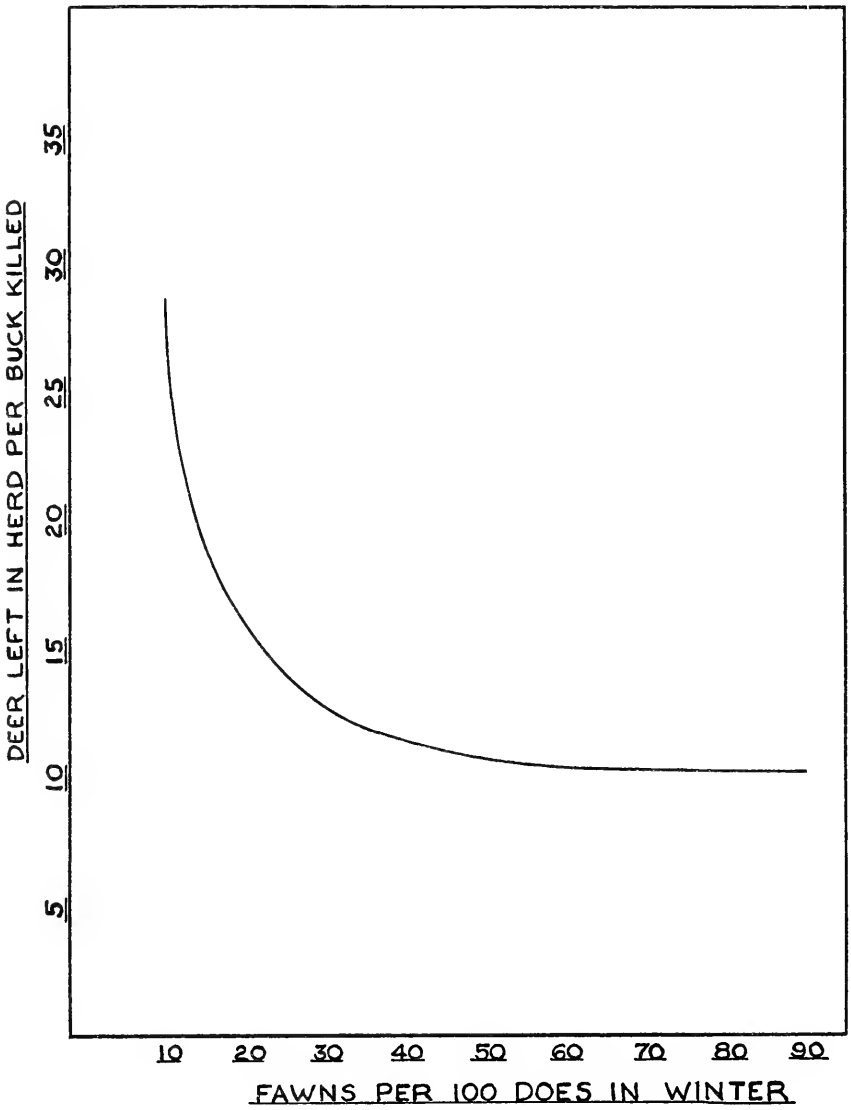

FIGURE 1. Relationship of maximum buck kill to population for herds where only adult bucks are legally taken

minimum figure for the number of deer in the population. This figure may then be modified upwards by comparison with other areas where more exact methods are used.

In using kill alone, the level of kill that the deer herd is actually sustaining must be known. This involves determination of the kill over a period of several years, since a single year's kill may be either above, or far below, the level usually sustained.

In areas where only adult bucks, two years old or older, are legally taken, the maximum possible kill that may be sustained by a population is equal to 9.5 percent, approximately, of the winter population. Thus, for each buck killed there will be about 10.5 deer remaining on the range. As the productivity of the herd decreases the number of deer on the range necessary to sustain a kill of one adult buck increases. The effect is shown in Figure 1.

TABLE 2

Number of Deer Remaining in Fall Population for Each Buck Killed During the Hunting Season

Winter ratio—Bucks per 100 does	Average late winter ratio—Fawns per 100 does									Average early winter ratio—Fawns per 100 does
	100	90	80	70	60	50	40	30	20	
20	8	8	9	10	11	13	15	19	29	100
			8	9	10	12	14	18	26	80
					9	10	12	17	24	60
							11	14	21	40
30	9	10	10	12	13	15	18	22	33	100
			9	11	12	14	16	21	31	80
					11	13	15	19	28	60
							13	17	25	40
40	11	12	12	14	15	17	22	30	43	100
			11	12	14	16	20	25	36	80
					13	15	18	23	33	60
							16	21	30	40
50	13	14	16	17	20	22	27	36	49	100
			14	16	18	20	25	31	45	80
					16	18	23	29	42	60
							20	26	38	40
60	17	18	20	21	24	27	34	48	50+	100
			18	20	22	25	32	41	50+	80
					20	24	29	37	50+	60
							26	34	49	40

In herds where yearling bucks are legally taken the maximum kill that may be sustained is determined by the minimum number of bucks in relation to does required for breeding purposes. If the minimum is one buck to 10 does, then the maximum yield that may be sustained is about one buck to every seven deer in the winter population, or a kill of about 14.5 percent.

Where does are legally hunted or where the illegal kill of does is an appreciable percentage of the buck kill, the percentage of the herd that may be killed on a sustained basis increases.

In most California herds the actual deer kill does not approach the maximum that may be sustained. Hence estimates based on the above ratios will usually be far too conservative. They may be raised to a more reasonable figure by comparison with the ratio of kill to population from herds of known size hunted under similar conditions.

Table 2 shows the number of deer left in the population for each legal buck killed for herds of varying sex ratios and varying rates of fawn survival. Such a table may be useful in arriving at an approximation of the number of deer on the range where exact data are lacking. In preparing this table, an allowance for an illegal kill of does equalling 20 percent of the total buck kill was provided. This increases slightly the percentage of the herd that is removed. It is assumed that yearling as well as adult bucks may be harvested. The assumptions made in this table are essentially the same as those discussed in relation to Table 1. The sources of error are equally operative. As previously indicated, these probably will tend in the direction of underestimating the population size.

To use Table 2, the field may may draw on his knowledge of approximate average sex ratios and approximate average ratios of fawns to does in the posthunting population and in the late winter. The table will then indicate the usual number of deer left in the population per buck killed in herds of such composition. A relatively constant hunting pressure is assumed, as well as relatively constant ratios, hence use of a single year's data may give misleading results. Accuracy may be more closely approached by actual field checks of density, and comparison with other areas.

SUMMARY

Determination of deer population size from kill data in combination with sex and age ratios is possible by the use of various published formulas. These formulas, however, require accurate field data which frequently are difficult to obtain. In the absence of these precise data, various sources of error are encountered which may have effects of considerable magnitude on population estimates. These sources of error tend to induce underestimation of the population size.

Where precise knowledge of population size is necessary, the time and labor required to obtain field data of sufficient accuracy for use in calculations from kill plus sex and age ratios should be weighed against that required to census a population by more direct means.

For a less exact measurement of population, approximations may be made from examination of kill data alone, or by comparison with known kill ratios from censused areas. A table giving approximate ratios of kill

to population for herds in which bucks only are hunted is presented. This table may be used by the field man who is in a position to determine roughly the average sex and age composition and deer kill from the herd with which he is working.

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RESULTS OF THE 1950 SPECIAL DEER HUNT ON MINERAL KING NATIONAL GAME REFUGE[1]

By HOMER F. BRYAN, Bureau of Game Conservation and WALTER I. LONG, Bureau of Patrol
California Department of Fish and Game

BRIEF HISTORY AND DESCRIPTION OF THE AREA

The Mineral King National Game Refuge is located in Sequoia National Forest, Tulare County, California, and is situated in an indentation of the southerly border of Sequoia National Park. It is bounded on the west, north and east sides by the park, and on the south by Sequoia National Forest and covers a total of 15,770 acres. It is accessible to automobiles by only one road which leads from Three Rivers up the east fork of the Kaweah River and terminates in the center of the refuge. The Mineral King Refuge occupies the huge amphitheater formed by the upper reaches of the east fork of the Kaweah River. The boundaries on the sides are high, jagged ridges and peaks ranging in elevation from 9,000 to 12,000 feet. The refuge was established by an Act of Congress in 1926 and is administered by the U. S. Forest Service, U. S. Department of Agriculture.

As approaching summer melts the snow up the east fork of the Kaweah River, the California mule deer (*Odocoileus hemionus californicus*), which have been wintering down that drainage in the area between Slapjack Creek and Milk Ranch Peak, begin their spring migration to the summer ranges on the Mineral King Refuge. The deer generally arrive on their summer range about the first of May and stay until the first heavy storms around the middle of November drive them down.

This deer herd is unique in that an overpopulation has occurred on the summer range rather than on the winter range which is generally the case in the rugged topography of the westerly slopes of the Sierra Nevada. This might be explained in part by the rather definite limits of the summer range and the encroachment of the heavy deer populations on the adjoining Sequoia National Park.

Since no livestock are permitted on the area, other than a few head of pack stock during the summer, the extreme hedging and highlining of the browse can be attributed only to the deer herd.

PRELIMINARY

For a number of years prior to the opening of the Mineral King National Game Refuge to public shooting, the Department of Fish and Game had been cognizant of the extremely high deer population summering on the area.

[1] Submitted for publication December, 1951. The writers wish to acknowledge with thanks the cooperation and aid given by members of the United States Park Service, United States Forest Service, and the California Department of Fish and Game, who assisted in conducting the hunt and in compiling of data used in this paper.

In the summer of 1950, after investigational work had shown that the range was being seriously damaged by browsing, the California Fish and Game Commission and the United States Forest Service, at the request of Central California sportsmen's groups, took the necessary steps to declare the refuge open to controlled deer hunting.

On August 28, 1950, 960 permittees were drawn by lottery from a list of hunter applicants at a temporary office of the Department of Fish and Game in Visalia, California. These hunters were then sent a special "hunter's choice" deer tag entitling them to a deer of either sex to be taken during a specified period of the special hunt.

A mobile checking station was established at the only road entrance to the refuge, and each hunter was issued a back tag for long-distance identification upon entering the hunt area. Each permittee was also given a specially prepared map of the area, and was individually briefed as to closed zones around places of habitation, regulations on indiscriminate shooting, and the reasons for the special hunt.

It was felt that the number of deer bagged by these hunters might relieve, temporarily at least, the pressure being exerted on the range. It would also remove some of the chronic camp-dwelling deer that were causing concern to the cabin owners for the safety of children spending the season at the summer homes.

RESULTS OF THE SPECIAL SEASON

To relieve the overcrowded hunting conditions and lessen the chances of accidents, the 30-day season was divided into eight hunting periods with 120 permittees eligible to hunt during each period. A total of 677 deer were legally taken by 870 hunters with an average success of 78 percent (Table 1).

TABLE 1

Results of the Mineral King Special Hunt by Periods

Period	Date	Bucks	Does	Total	Hunters participating	Hunter success (percentage)
1	9/16- 9/18	83	33	116	117	99
2	9/19- 9/22	79	36	115	116	99
3	9/23- 9/25	63	43	106	115	92
4	9/26- 9/29	62	33	95	104	91
5	9/30-10/2	34	43	77	105	73
6	10/3 -10/6	20	41	61	104	59
7	10/7 -10/10	35	20	55	100	55
8	10/11-10/15	18	34	52	109	48
Totals	9/16-10/15	394	283	677	870	78

The cold snap which occurred just prior to the first of October started the deer drifting slowly down the drainage and a considerable number of deer became unavailable to the hunters because of their movement into the park. The drop in hunting success shown between periods 4 and 5 reflects this movement. Previous to that time, very little movement of deer from the refuge into the park had been noted. In fact, on the first day of the special shoot, fourteen bucks were seen moving into the refuge from Farewell Gap.

TABLE 2

Sex and Age Classification of Deer Killed
Mineral King Special Hunt

	Male	Female	Total	Percent
Fawns	23	23	46	7
Yearlings	51	22	73	11
Adults	320	238	558	82
Totals	394	283	677	100
Percent	58	42	100	

Table 2 shows the kill by sex and age classification. All deer were checked for age by examining the teeth. Yearlings were easily recognized by the presence of the deciduous first canine (fourth incisor), or the deciduous fourth premolar. It is interesting to note that of the 51 yearling bucks, 44 (86 percent) were spikes and the remaining 7 (14 percent) were forked-horns. In addition there were two spikes taken which were over yearling age.

Mineral King is bounded on the south by Sequoia National Forest, an area open to public shooting which is utilized by many sportsmen each year. In the course of the 1950 season 48 bucks which had been killed in the open area to the south of the special hunt section were checked at the Mineral King station. Table 3 presents the point-classes of bucks taken outside the refuge as compared with those taken inside.

TABLE 3

Number and Percentage of Bucks Checked Out at Mineral King Checking Station

Area where killed	Point classes						Totals
	None	1	2	3	4	5+	
In refuge							
Number	23	46	96	110	95	24	394
Percent	6	12	24	28	24	6	100
Percent (two-point or more)	-------	-------	30	34	29	7	100
Outside refuge							
Number	-------	-------	23	15	9	1	48
Percent (two-point or more)	-------	-------	48	31	19	2	100

An attempt was made during the season to determine the number of deer lost to illegal kill and crippling. As dead or crippled deer were reported by hunters and packers to Department of Fish and Game personnel, the area was immediately checked and the ears of the dead deer docked after recording the sex and age.

In addition to this running check during the hunt, two days were spent immediately after the close of the season covering the area to make as comprehensive a count of dead deer as possible. Dead deer recorded earlier were easily recognized by the docked ear.

A total of 26 dead deer was recorded during and after the hunt. Of these, 17 were bucks and 9 were does. Only two of the 26 deer noted were fawns. This shows a loss due to crippling and illegal kill of 4 percent of the total reduction. Some deer were undoubtedly overlooked; however, it is felt that the constant check kept on hunter's reports during the season and the additional intensive postseason search revealed a major portion of the deer wasted to illegal kill and crippling loss.

There are two factors which could have been the major reasons for such a small loss. First, some hunters were purposely shooting crippled deer in preference to other animals. Second, wardens carried out intensive patrol activities on the refuge. Hunters knew that wardens were equipped with binoculars and felt that they might be under surveillance at any time. This tended to reduce much of the indiscriminate shooting.

TABLE 4

Game Cases—Mineral King Special Hunt

Offense	Number arrests	Fine collected	Jail sentence (days)
Deer: Taking deer in Mineral King Refuge without a special permit	1	$50	
Deer: Overlimit	1	25	
Hunting: Hunting in refuge without a special permit	2	25	87½
Totals	4	$100	87½

There were no accidents reported during the entire hunt, but four arrests were made for game law violations. Table 4 shows the breakdown of these cases with fines and jail sentences imposed.

SUMMARY

1. The Mineral King National Game Refuge is located in Sequoia National Forest, Tulare County, California, and is bounded on three sides by Sequoia National Park. This refuge summers a high population of deer and the range shows evidence of extreme overuse.

2. After state and federal agencies had taken the necessary steps to open the refuge to public shooting, 960 permittees were drawn by lottery and sent a special deer tag entitling them to a deer of either sex to be taken during one of the eight specified periods.

3. The average success for the 870 hunters who participated was 78 percent for a total of 677 deer legally taken.

4. Of the 394 bucks and 283 does taken, 46 were fawns, 73 yearlings, and 558 were adults.

5. A greater percentage of bucks in the 3-point and better classes were taken inside of the refuge than from an open area outside the refuge (Table 3).

6. Checks for crippling loss and illegal kill show that at least 26 deer were lost to these causes, 4 percent of the total legal kill.

7. Four arrests were made during the special season and sentences totaling $100 in fines, and 87½ days in jail were imposed.

OBSERVATIONS ON THE OCCURRENCE OF TUNAS IN THE EASTERN AND CENTRAL PACIFIC[1]

By H. C. GODSIL and E. C. GREENHOOD
Bureau of Marine Fisheries
California Department of Fish and Game

On September 13, 1948, the Department of Fish and Game research vessel N. B. SCOFIELD returned from a 9,000-mile, eight-week trip into the central Pacific. The area investigated was primarily the Hawaiian chain of islands and banks, and the north Pacific lying between these islands and the American mainland. A mimeograph report of this trip was submitted to the industry, but it did not receive wide circulation. Due to continued interest in this area on the part of fishermen, biologists and the industry, this report is presented with some modifications and additions.

On the trip to the islands (sailing from Los Angeles harbor on July 21, 1948) and again on the return passage, we explored the distribution of albacore (*Thunnus germo*) on the surface in the intervening ocean; in the Hawaiian region we attempted to get adequate samples of yellowfin tuna (*Neothunnus macropterus*), albacore, and skipjack (*Katsuwonus pelamis*) in order to determine whether or not these fish are of the same or a different stock from those of the eastern Pacific. Earlier studies of the few specimens available indicated that the populations were distinct (Godsil, 1948) and subsequent studies have borne this out (Godsil and Greenhood, 1951; Schaefer, ms.).

YELLOWFIN AND SKIPJACK

The course of the N. B. SCOFIELD in the Hawiian region covered primarily the various shoal spots and the chain of banks extending west and north of Oahu, and as far south as Johnston Island (Figure 1). Throughout this area skipjack were found in abundance, both on the banks and in the open ocean, but yellowfin were relatively scarce. On a course from Honolulu to Johnston Island, schools of skipjask were seen. These fish were at least a hundred miles from any land or charted bank, and were encountered in areas where the charts showed depths of 2,500 fathoms or more. Of these schools some consisted of large fish, averaging perhaps 25 pounds apiece. In these cases the entire school appeared to consist of large fish. All catches are listed in Table 1 by date and place of capture.

Continuing westward toward Johnston Island (approximate position 17° north latitude, 170° west longitude) an abundance of fish was found in the immediate vicinity of the island and in the direction of one or more outlying banks. Of these fish the majority were skipjack of small

[1] Submitted for publication, November, 1951.

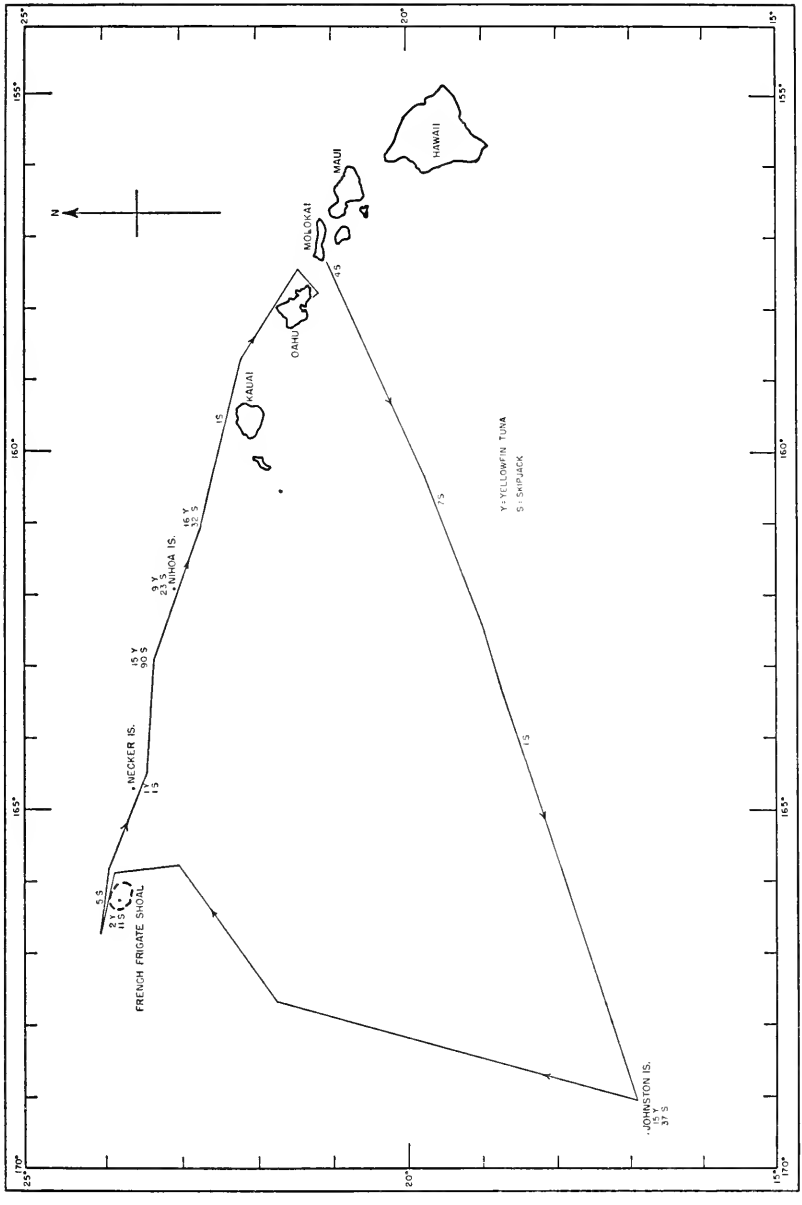


FIGURE 1. Course taken by the *N. B. Scofield* in the Hawaiian Island area showing location of tuna catches

to medium size. Yellowfin tuna were present but not in evident abundance. A few were caught with skipjack but it appeared as though the yellowfin were deeper, remaining below the schools of skipjack, and coming to the surface occasionally. The size of these yellowfin ranged from about eight to 30 pounds. No schools of yellowfin, exclusively, were seen at the surface.

From Johnston Island the N. B. Scofield proceeded north and followed a finger-like bank projecting southwest from Necker Island. On this course only skipjack were taken, and relatively few schools were seen.

Subsequent fishing operations extended from French Frigate Shoal in the west to the Island of Oahu. A continuous series of banks extends between these points, and each of these was investigated. We found an abundance of fish on all the shallower banks throughout this area. Skipjack predominated, but yellowfin were present also. Our impression was that yellowfin were relatively scarce. As at Johnston Island the latter were taken with skipjack; and again it appeared that the yellowfin were deeper, feeding beneath the schools of skipjack and coming to the surface only occasionally. Throughout this area the smaller and medium-sized skipjack predominated and large specimens were the exception. Likewise the yellowfin in this region were mostly small, up to 30 pounds, and no large yellowfin were taken here.

As a general rule we found black skipjack (*Euthynnus* sp.) exclusively on the shallowest spots (in water of 10 to 20 fathoms). As the water deepened to 30 and 40 fathoms skipjack became more abundant and the black skipjack less numerous. The best fishing was found on the slope of the banks, where the depth increased rapidly from 40 or 50 fathoms to the prevailing depth in the general vicinity. As the banks proper were left astern fish decreased rapidly in abundance.

Working birds were the best indicators of fish. Sometimes fish were actually seen at the surface, but rarely were fish caught without birds in the immediate vicinity.

The area to the north of this chain of banks was subsequently investigated, but no skipjack or yellowfin were caught after leaving the general proximity of the banks. It appeared as though the Hawaiian chain marked the northern boundary of the yellowfin and skipjack populations.

Most of the specimens caught were taken on trolling lines. No trolling was done close to the reefs. A few were caught experimentally in drift gill nets. No attempts were made to fish with live bait or long lines. As is generally known, bait is relatively scarce in this chain, and we did not feel justified in taking time to explore the various bait grounds.

Our impressions concerning the fish in this area were that the fish were "wild." We followed the birds working over schools, and it proved a difficult job to approach the schools which moved rapidly and erratically. On only a few occasions were schools relatively stationary.

At times when passing under the birds, dolphins (*Coryphaena hippurus, C. equisetis*) and wahoo (*Acanthocybium solandri*) were taken by trolling lines, so that the presence of birds did not always indicate tuna.

The weather throughout this region is governed by the prevailing trade winds. Unlike the eastern Pacific there is generally a brisk northeast breeze with a corresponding slight to moderate sea running. Conditions

are quite different from those to which our tuna boats are accustomed, and it is our opinion that regular bait boats could not operate successfully, without modification, in the Hawaiian area. Our vessels would roll excessively under prevailing weather conditions, and the racks and rails would be under water a great part of the time. Moreover, bait is definitely

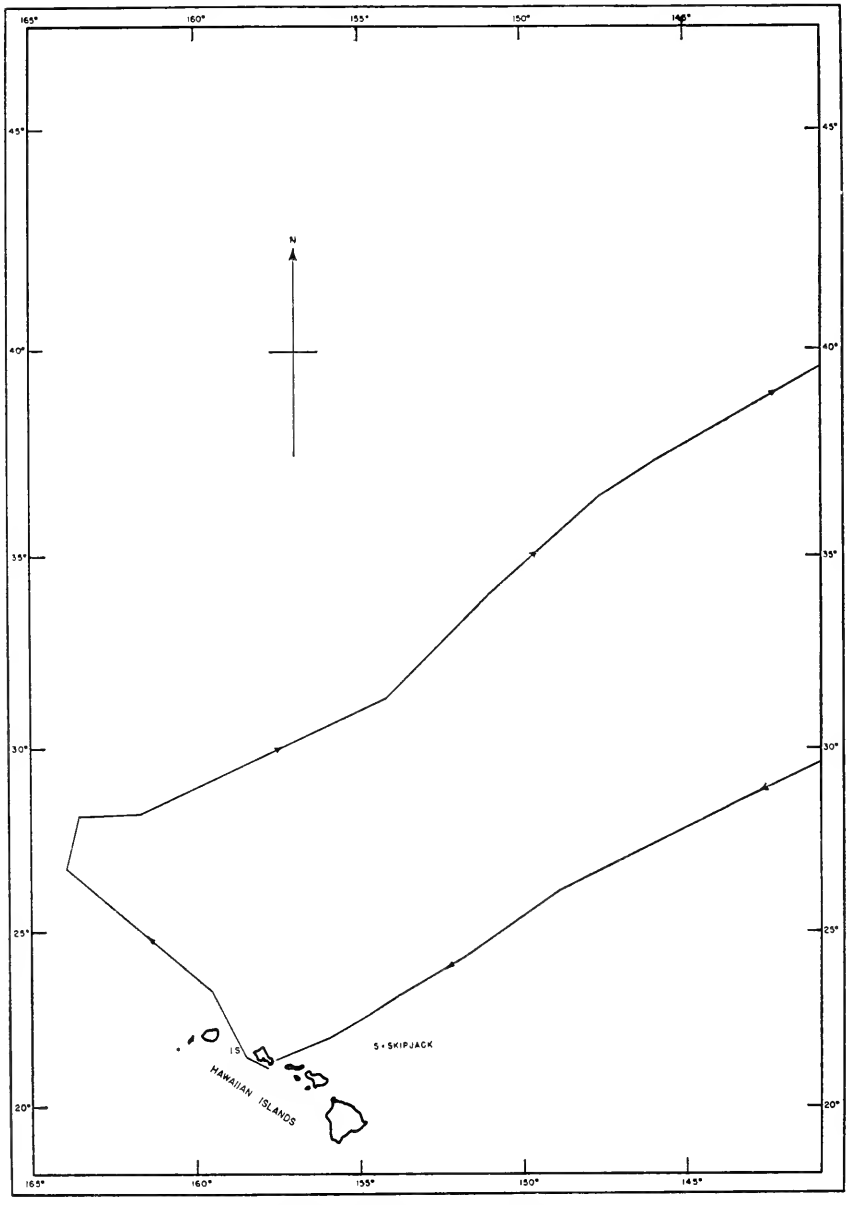
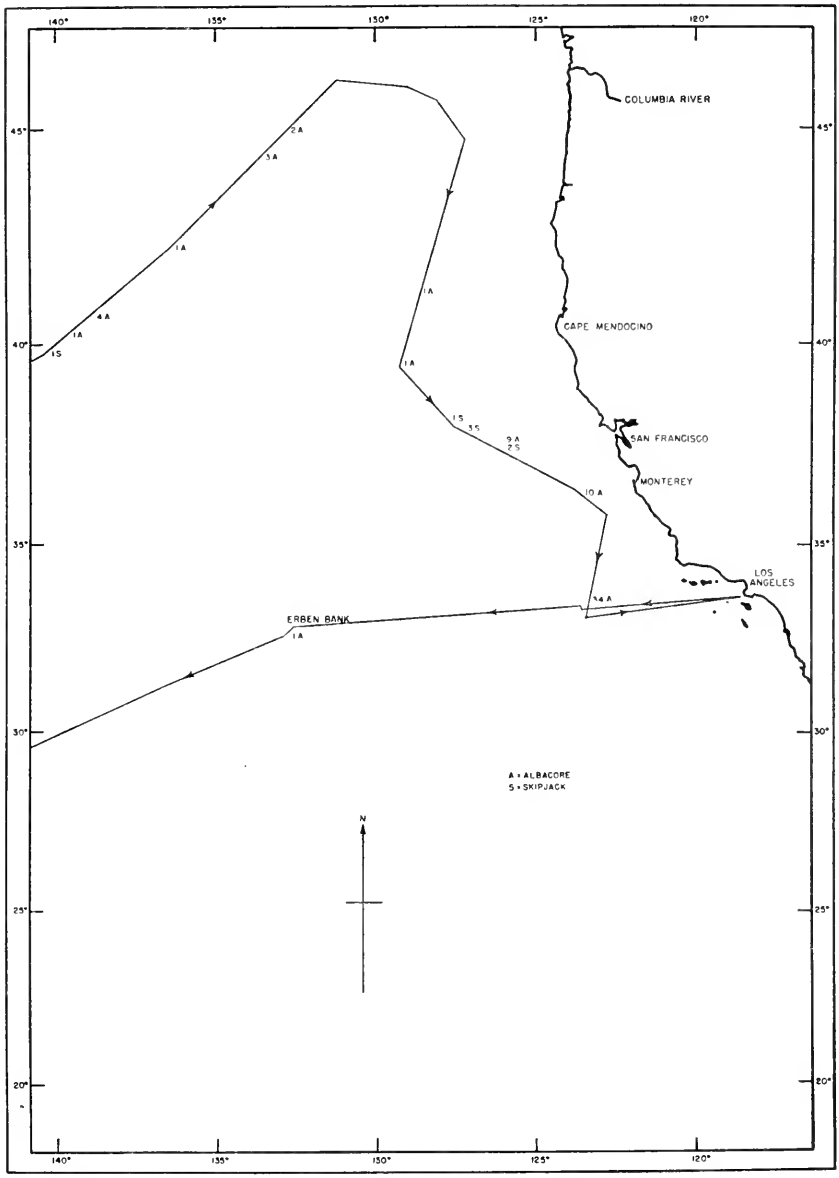


FIGURE 2. Course taken by the *N. B. Scofield* en route to and re-

scarce (June, 1951) and an excessive amount of time would be required to secure it. Purse seining likewise would be extremely difficult, both because of weather and the wildness of the fish. On occasional days the behavior of the fish and weather conditions would permit purse seining, but in the four weeks spent in this region such days were rare.



turning from the Hawaiian Islands showing location of tuna catches

TABLE 1

Fishing Stations Occupied on the 1948 Hawaiian Cruise of the "N. B. Scofield" Showing the Approximate Positions, the Gear and the Resulting Catch

Date	Station	Position	Catch	Gear
July 22	588	33°21′N to 33°18′N 122°31′W 123°48′W	12 albacore	Trolling lines
July 24	589	about 32°38′N 132°54′W	Lower jaw of 1 albacore	Trolling lines
July 29	590	24°14′N to 23°17′N 151°48′W 153°39.6′W	15 dolphin	Trolling lines
July 30	591	22°27.3′N to 21°37′N 154°58′W 156°43′W	2 dolphin	Trolling lines
July 31	592	Penguin Bank to 20°54′N Molokai, T.H. 157°46′W	4 skipjack 3 black skipjack 1 dolphin	Trolling lines
Aug. 1	593	19°34.5′N to 19°31′N 160°53′W 161°05′W	7 skipjack	Trolling lines
Aug. 2	594	18°58.7′N to 18°24′N 162°27.8′W 164°18′W	1 skipjack	Trolling lines
Aug. 4	596	Johnston Island 12–15 miles 126°T. from Island	6 yellowfin tuna 13 skipjack	Trolling lines
Aug. 4–5	597	16°37′N 169°21′W	1 shark 1 file fish	Drift gill nets
Aug. 5	598	Johnston Island	7 yellowfin tuna 1 skipjack	Trolling lines
Aug. 5–6	599	16°31′N 169°25′W	1 skipjack 1 file fish	Drift gill nets

Aug. 6	600	Johnston Island	4 skipjack	Trolling lines
Aug. 7	601	Johnston Island	2 yellowfin tuna 18 skipjack	Trolling lines
Aug. 10–11	603	23°52.5′N 165°53′W	2 unidentified specimens 8 shark	Drift gill nets
Aug. 10	604	French Frigate Shoal	2 yellowfin tuna 8 skipjack	Trolling line and hook and line
Aug. 11	606	French Frigate Shoal	3 skipjack 1 dolphin	Trolling lines
Aug. 12	607	24°02′N to 23°56′N 166°41′W 165°52′W	9 black skipjack 5 skipjack	Trolling lines
Aug. 13	608	S.E. of Necker Island 23°23′N 164°27′W	20–25 black skipjack 1 skipjack 1 yellowfin tuna 3 dolphin	Trolling lines
Aug. 14	609	Within seven mile radius of 23°14′N 162°56′W	12 yellowfin tuna 50 skipjack 20–30 black skipjack	Trolling lines
Aug. 15	610	Within five mile radius of 23°14′N 162°50′W	40 skipjack 30 black skipjack 1 wahoo	Trolling lines
Aug. 15–16	611	23°24′N 163°05′W	3 small yellowfin tuna 1 Big-eyed scad *Trachurops crumenophthalmus* 1 Decapterus *Decapterus pinnulatus* 1 file fish 1 shark	Drift gill nets
Aug. 16	612	Vicinity of Nihoa Island	9 yellowfin tuna 23 skipjack 10–15 black skipjack 1 wahoo	Trolling lines

TABLE 1—Continued

Fishing Stations Occupied on the 1948 Hawaiian Cruise of the "N. B. Scofield" Showing the Approximate Positions, the Gear and the Resulting Catch

Date	Station	Position	Catch	Gear
Aug. 17	613	Within ten mile radius of 22°42′N 161°04′W	16 yellowfin tuna 32 skipjack 15–20 wahoo 10–20 black skipjack 1 rainbow runner *Elagatis bipinnulatus*	Trolling lines
Aug. 18	614	22°28′N 159°41′W to and along N. coast of Kauai	1 skipjack 2 dolphin	Trolling lines
Aug. 24	615	Honolulu to S. W. end of Island	2 wahoo 1 skipjack	Trolling lines
Aug. 28	617	28°51′N 160°08′W to 29°40′N 158°05′W	2 dolphin	Trolling lines
Sept. 1	618	36°15′N 147°54′W to 37°19′N 146°00′W	3 dolphin	Trolling lines
Sept. 2	619	37°59′N 144°30′W to 39°00′N 142°10′W	3 dolphin	Trolling lines
Sept. 3	620	39°49′N 140°22′W to 40°53′N 138°43′W	1 skipjack 5 albacore	Trolling lines
Sept. 4	621	42°12′N 136°36′W	1 albacore	Trolling lines
Sept. 5	622	43°55.5′N 134°20′W to 45°08′N 132°29′W	5 albacore	Trolling lines

Sept. 8	624	41°26′N to 39°29′N 128°31′W 129°13′W	2 albacore	Trolling lines
Sept. 9	625	38°15′N to 37°16′N 127°52′W 125°49′W	9 albacore 6 skipjack	Trolling lines
Sept. 10	626	36°30′N to 35°40′N 123°50′W 122°44′W	10 albacore	Trolling lines
Sept. 11	627	Various courses near 33°15′N 123°15′W	22 albacore	Trolling lines

ALBACORE

The distribution of albacore in the eastern portion of the Pacific was investigated on the outward and on the return trip. A course was set from San Pedro roughly due west to Erben Bank, and then directly to the Island of Oahu. The return voyage was made from Honolulu northward to a point about 500 miles west of the Columbia River. Throughout this entire extent the N. B. SCOFIELD trolled for albacore during the daylight hours, and each strike and every fish caught was recorded (Figure 2).

Leaving San Pedro on July 21, 1948, we encountered albacore at a distance of approximately 150 miles west of San Nicolas Island, and caught occasional fish in this general region. Nothing was found on Erben Bank, although the weather was fine and soundings were obtained. After leaving Erben Bank we pulled in the jaw of an albacore at a distance of approximately 35 miles beyond the bank. This was the last strike we had, and no fish were caught, nor evidence of fish seen on the balance of the passage to the islands.

Not a single albacore was taken south of the Hawaiian chain. Seven specimens were seen in the Honolulu markets but apparently albacore are scarce there, at least in this season, and are caught only on set lines at a depth of approximately 30 fathoms in conjunction with a small set line fishery for large yellowfin, big-eye tuna (*Parathunnus mebachi*) and spearfishes.

Upon leaving Honolulu for California the N. B. SCOFIELD proceeded northwest to a point approximately 150 miles north of Necker Island, thence northward for a day's run and then generally northeastward to the Columbia River. This course was set to investigate the areas in the north Pacific where the occurence of albacore (Bennett, 1840; Brock, 1943) had been reported previously. Contrary to expectations, no albacore were encountered in the Hawaiian region and no fish were caught until the N. B. SCOFIELD arrived at a point approximately 700 miles due west of Cape Mendocino. From this point, scattered albacore were caught daily on a course toward the Columbia River. All these fish were small, and at no time were fish, or indications of fish, actually seen at the surface. We trolled "blind." The fact that two or more fish were frequently taken simultaneously on the trolling lines would indicate, however, that more than straggling fish were present in this area.

Reaching the vicinity of the Columbia River the courses were laid out to explore the distribution of albacore on and offshore. We found albacore at various points along the entire coastline at distances of approximately 200 miles or less from shore. In three regions albacore appeared to be relatively abundant (Sept. 9-11). The first region was located approximately 180 miles due west of Pigeon Point, California. The second centered approximately 75 miles west of Point Sur, extending from the latitude of Monterey down to that of Piedras Blancas. The third region was approximately 200 miles off San Nicolas Island, and here albacore were taken in considerable abundance. The last region, and to a lesser extent the second one, are areas where albacore have been encountered on a number of occasions. Early in July, prior to the opening of the 1948 season, the N. B. SCOFIELD found and reported albacore in fair abundance in both these regions.

From this and other scouting work conducted by the Department of Fish and Game it appears that there might be an on- and offshore movement of albacore in season. Observations suggested that albacore may be available in the offshore grounds when none are present off the immediate coast line. Perhaps the season could be extended by early and late fishing farther off the coast, particularly in the two general regions described above.

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TOXICITY AND TAXONOMIC NOTES ON THE SQUARETAIL, *TETRAGONURUS CUVIERI*[1]

By JOHN E. FITCH
Bureau of Marine Fisheries
California Department of Fish and Game

In the Mediterranean region where *Tetragonurus* is most frequently captured the flesh has long been considered poisonous (Risso, 1810). On at least two occasions Risso became extremely ill after eating this fish. From his account we find that for a period of at least two days he suffered intense pain in the pit of the stomach, swelling of the abdomen, a distressing heat in the throat, frequent nausea and some tenesmus and lassitude of all the limbs. He believed that *Tetragonurus* was particularly dangerous during the summer months when it fed upon considerable numbers of small jellyfish, genus *Stephanomie*. This jellyfish is considered extremely toxic (Seurat, 1933) and the toxicity is presumably passed on to the squaretail. To the writer's knowledge there have been no chemical tests made on *Tetragonurus* in the Mediterranean. Where reference has been made to its poisonous qualities most workers have been satisfied to quote the results of the "taste" test reported by Risso (Seurat, 1933; Guiglia, 1950).

Capture of four *Tetragonurus* some 60 miles off Point Conception, California, during May, 1950 (Fitch, 1951), afforded an excellent opportunity to test the flesh of this species from California waters. Examination of stomach contents of these fish revealed remains of coelenterates and ctenophores, unidentifiable to genera. Fillets and livers were shipped frozen to the George Williams Hooper Foundation in San Francisco for testing. Analysis of this material yielded less than one mouse unit of poison per gram of meat. A mouse unit is the amount of poison that will kill a 20 gram mouse in 15 minutes when administered intraperitoneally in a one cubic centimeter dose. From this it may be assumed that the flesh and livers of *Tetragonurus* taken in California waters during May, 1950, were not poisonous. If toxicity of this species is due to the material upon which it feeds there is a possibility that the fish would be poisonous during other months of the year or during the same month in other years. More toxicity experiments must be performed before broad statements concerning the species can be made.

Examination of a recently caught California *Tetragonurus* was made possible through the courtesy of Dr. Carl L. Hubbs, Scripps Institution of Oceanography, La Jolla. This specimen (field notebook H 50-289) was taken off Santa Catalina Island on December 8, 1950 in an experimental middepth trawl by Dr. John Isaacs. Counts and measurements are: Counts: dorsal fin XVIII, 12; anal fin 1, 12; pores on lateral line to keels

[1] Submitted for publication October, 1951.

100; transverse scales, above lateral line 8, below lateral line 21; teeth, upper left 12, lower left 21; gill rakers on outer arch 6 + 11. Measurements: (standard length is in millimeters, all others are expressed as percent of standard length) standard length 60 mm.; total length 111.7; head length 26.7; depth 17.5; pectoral fin 14.3; ventral fin 7.8; eye 7.3; maxillary 10.3; snout 8.3; snout to insertion of first dorsal 35.0; snout to second dorsal insertion 56.7; snout to anal insertion 62.5; snout to ventral insertion 32.2; snout to anal opening 59.2; snout to first nare 4.7; snout to second nare 6.7; first dorsal to second dorsal 25.0; base second dorsal 12.0; base anal 10.5.

These counts and measurements fit in well with those of seven other California specimens (Fitch, 1951). The tooth count substantiates the theory that there is an increase in number with increase in length of the fish. On the other hand the 18 dorsal spines in this small specimen total one more than previously recorded for California *Tetragonurus* and indicate that dorsal spines do not increase in number with age as previously suggested. In support of this a close examination of the X-ray of the Davidson Sea Mount specimen (Fitch, 1951) revealed no developing spines in the dorsal outline of the fish.

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A REVIEW OF THE PACIFIC MACKEREL (*PNEUMATOPHORUS DIEGO*) FISHERY OF THE LOS ANGELES REGION WITH SPECIAL REFERENCE TO THE YEARS 1939-1951 [1]

By PHIL M. ROEDEL
Bureau of Marine Fisheries
California Department of Fish and Game

INTRODUCTION

Although Pacific mackerel were canned on an experimental basis as early as 1904, it was not until 1928 that the present day industry got its start. The first few years were fraught with economic troubles but since 1933 the fishery has been one of major importance in California. It is the purpose of this article to review the Los Angeles fishery over the period 1928-1951, with special emphasis on the years since 1938. Two previous publications (Croker, 1933, 1938) present detailed discussions of most of the earlier years, and much of the data regarding them is drawn from these papers.

FISHING PORTS

The mackerel fishery is and has been centered in Southern California, with the great bulk of the catch delivered at ports in the Los Angeles region (Los Angeles and Orange counties) for processing at Los Angeles-Long Beach Harbor and, since 1935, Newport Beach canneries. Most fares are delivered dockside at the plants, but at times large tonnages have been landed at smaller ports such as Redondo Beach and Santa Monica for transshipment to the canneries. Deliveries to the Los Angeles region have ranged from 83 to 99 percent of the annual state-wide catch, have exceeded 90 percent since 1937 and 95 percent since 1944. For the past ten years, landings at San Diego have been inconsequential, but in 1928 and 1929 and in the period 1933-1939 considerable quantities representing up to 16 percent of the state-wide catch were delivered and processed at the port. San Diego canneries now devote their attention exclusively to the tunas. Over the years, the Santa Barbara region has received a very small proportion of the catch. Just before World War II, canneries were established at Port Hueneme, but the entire port was shortly taken over by the Navy. Civilian control over parts of the facilities was re-established after the war, and some mackerel are now delivered there for local processing or transshipping elsewhere. Total deliveries at Hueneme have never exceeded 4 percent of the annual landings. Monterey is the only Northern California port to receive mackerel in any quantity. Landings of over 2,500 tons and representing 4 to 5 percent of the state-wide

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catch were received in 1934, 1935, and 1936. The 1943 landings of 2,215 tons were by far the greatest since that time. Annual landings by regions are presented in Table 1.

TABLE 1

Annual Landings in Tons of Pacific Mackerel

Year	Region					Total
	San Francisco	Monterey	Santa Barbara	Los Angeles	San Diego	
1928	1	648	7	15,615	1,354	17,625
1929	16	511	4	23,945	4,511	28,987
1930	6	682		7,237	341	8,266
1931	1	628	19	6,373	107	7,128
1932	2	333	2	5,810	89	6,236
1933		676	13	29,447	4,669	34,805
1934	2	2,562	12	48,564	5,785	56,925
1935	8	2,736	21	65,816	4,633	73,214
1936	22	2,709	12	42,155	5,370	50,268
1937	6	1,010	16	27,738	1,700	30,470
1938	1	741	18	36,985	2,178	39,923
1939		414	15	36,827	3,198	40,454
1940		226	171	58,031	1,824	60,252
1941	16	912	264	37,378	834	39,404
1942	61	401	544	24,367	904	26,277
1943	191	2,215	46	34,849	330	37,631
1944		276	38	41,457	58	41,829
1945	1	228	71	26,415	143	26,858
1946		962	5	25,851	120	26,938
1947		187	723	22,160	169	23,239
1948	1	77	488	18,906	203	19,675
1949	2	117	83	24,459	225	24,886
1950	10	193	446	15,400	276	16,325

FISHING METHODS

Fishing methods employed by Los Angeles region fishermen have changed greatly over the years and mackerel can be and have been taken by many types of gear. Prior to the development of the canning industry, the relatively limited fresh fish trade was supplied largely by hook and line fishermen. Hook and line fishing could not, however, provide fish in bulk, and the canners' demands were met initially by lampara boats. These vessels were dominant for the first few years, but with the expansion of the industry in 1933, purse seiners found the fishery profitable and by the end of 1935 surpassed the lamparas in importance. Lamparas had virtually disappeared from the fishery in 1937. Catches made by the net boats fell off in the years following 1935 and by 1939 the seiners were no longer able to meet the demand. The gap was filled by a large fleet of small boats carrying crews of one to three men who employed the methods of striker fishing and "scooping." Scooping was an outgrowth of striker fishing—attracting mackerel with ground bait and catching the fish on bamboo poles with feathered, barbless hooks. The striker fleet had played a part in the early years of the cannery fishery (1928-1929) but had been virtually dormant from 1930 to 1933. These boats became active with the expansion after 1933 and found a permanent place in the mackerel industry with the opening of canneries at Newport Beach in 1935. The fishery out of that port was then and remains today

the province of the small boat operator. Striker fishing, though not unprofitable, did not permit capture of mackerel in quantity in a short time. Meantime someone had discovered that mackerel attracted by ground bait could be caught in numbers with a long-handled widemouthed dip net, and this implement, the scoop, first appeared in the fishery in 1933. The technique evolved over the years, and by 1940 was perfected to the extent that scooping at night was supplanting striker fishing by day.

This scoop fleet, numbering in its heyday into the hundreds, has accounted for over half of the total mackerel catch since 1939. In only two seasons since that year has the seiner catch exceeded the scoop. However, since the war many canners have refused to accept scoop fish, and by 1950 very few outside of Newport Beach remained in the market.

PRICE

Prices paid by the canners to the fishermen have reflected increased demand, increased costs, and, in recent years, fluctuating markets for the canned product. In the prewar years, the price per ton rose from $10 at the start of the 1933 season to $15 in 1935, $18 in 1936, $21 from 1937 through 1940 and to $27.50 in 1941. During the war years 1942-1945, the price was set at $40. Since 1945, there have been marked fluctuations within and between seasons. First there was a steady rise to the peak of $75 which held with fair stability from January through September 1948. This peak was followed by a period of flux with prevailing prices ranging from as little as $30 for part of the November, 1949, catch up to $60. At the close of the 1950-51 season, the price stood at $55.

FISHING SEASON

Mackerel are seasonal in their occurrence on the Southern California fishing grounds. There is a period of scarcity of varying length which usually centers in April and catches are at a peak in the fall. For this reason, the fishery is regarded as commencing in May and ending the following April.

TREND OF THE TOTAL CATCH, 1928-29–1950-51

Landings by month and season are presented in Table 2, Figure 1 and Figure 2.

In the first season of large-scale canning operations, 1928-29, over 17,000 tons of mackerel were processed, and in the following season over 23,000. In the ensuing three seasons, 1930-31 through 1932-33, economic factors sharply limited the take, which varied from 5,000 to 7,000 tons per season. There was a marked resurgence in 1933-34, with total landings rising to 30,000 tons. The rise in catch continued in 1934-35 and in 1935-36, the tonnage surpassed 65,000, the greatest seasonal catch on record.

TABLE 2

Landings in Tons of Pacific Mackerel, Los Angeles Region, 1928-29–1950-51

	Season								
	1928-29	1929-30	1930-31	1931-32	1932-33	1933-34	1934-35	1935-36	1936-37
May	678	3,281	381	254	912	614	3,248	6,797	3,956
June	222	2,498	550	685	427	4,408	2,407	6,544	1,909
July	1,197	3,955	459	453	319	5,229	5,774	2,747	8,214
August	2,077	1,356	134	865	361	3,550	7,024	4,455	4,153
Early season	4,174	11,090	1,524	2,257	2,019	13,801	18,453	20,543	18,232
September	2,587	3,570	205	542	613	4,273	11,687	9,612	7,901
October	4,031	2,768	2,224	996	123	7,532	8,250	14,215	11,414
November	1,910	2,266	653	439	1,457	1,624	5,251	11,744	528
December	1,864	1,193	112	1,325	83	1,548	3,629	8,227	3,147
Midseason	10,392	9,797	3,194	3,302	2,276	14,977	28,817	43,798	22,990
January	1,388	805	322	724	137	286	562	157	1,351
February	1,043	710	229	342	354	513	756	122	119
March	397	741	184	310	96	416	62	504	183
April	230	263	79	139	82	79	95	150	174
Late season	3,058	2,519	814	1,515	669	1,294	1,475	933	1,827
Season totals	17,624	23,406	5,532	7,074	4,964	30,072	48,745	65,274	43,049

TABLE 2—Continued

Landings in Tons of Pacific Mackerel, Los Angeles Region, 1928-29–1950-51

	Season									
	1937-38	1938-39	1939-40	1940-41	1941-42	1942-43	1943-44	1944-45	1945-46	1946-47
May	1,393	2*	20*	45*	27*	68	40	142	131	193
June	809	162	529	53*	53*	92	112	73	64	67
July	2,920	1,386	1,262	275	1,364	34	70	144	31	59
August	6,458	10,324	2,884	2,026	1,225	22	1,447	831	517	168
Early season	11,580	11,874	4,695	2,399	2,669	216	1,669	1,190	743	487
September	4,994	5,575	3,777	4,412	5,945	1,304	5,095	11,138	3,537	5,511
October	4,126	3,204	5,032	16,538	10,357	6,083	7,910	11,439	7,326	4,236
November	3,641	2,764	9,680	13,659	7,681	8,537	12,447	7,484	6,892	5,175
December	1,570	6,767	8,562	6,742	2,614	3,913	4,941	6,098	5,248	8,623
Midseason	14,331	18,310	27,051	41,351	26,597	19,837	30,393	36,159	23,003	23,545
January	4,702	4,620	7,506	2,901	2,235	1,685	3,260	2,099	1,314	2,130
February	1,144	5	4,823	4,114	698	772	665	365	286	1,449
March	954	442	1,950	1,035	1,340	319	115	40	147	622
April	1*	14*	2*	62*	41	11	68	165	72	99
Late season	6,801	5,081	14,281	8,112	4,314	2,787	4,108	2,669	1,819	4,300
Season totals	32,712	35,265	46,027	51,862	33,580	22,840	36,170	40,018	25,565	28,332

* Voluntary closed season.

TABLE 2—Continued

Landings in Tons of Pacific Mackerel, Los Angeles Region, 1928-29–1950-51

	Season				23-season totals	
	1947-48	1948-49	1949-50	1950-51	Tons	Percentage
May	117	175	106	336	22,916	3.4
June	163	64	713	290	22,894	3.4
July	623	1,120	2,561	1,917	42,113	6.2
August	1,531	2,729	4,670	1,586	60,393	8.9
Early season	2,434	4,088	8,050	4,129	148,316	21.9
September	5,493	4,924	6,319	6,654	115,668	17.1
October	4,874	5,586	5,638	1,714	145,616	21.6
November	4,503	2,189	3,200	1,628	115,352	17.1
December	556	1,326	953	825	79,866	11.8
Midseason	15,426	14,025	16,110	10,821	456,502	67.6
January	238	161	82	280	38,945	5.8
February	244	3	50	51	18,857	2.8
March	265	88	186	94	10,490	1.6
April	46	47	132	545	2,596	0.4
Late season	793	299	450	970	70,888	10.6
Season totals	18,653	18,412	24,610	15,920	675,706	100.1

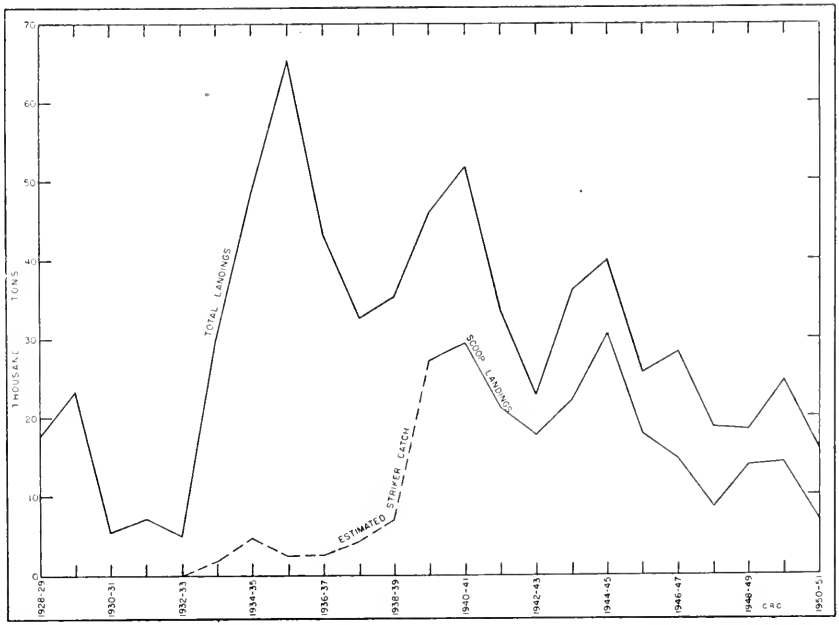

FIGURE 1. Seasonal landings of Pacific mackerel in the Los Angeles region, showing the vast increase in importance of the fleet of small boats which fished chiefly with strikers in the early years and later adopted the technique of scooping

Since 1935-36, despite generally favorable market conditions, the trend of the catch while erratic has been steadily downward. There have been marked fluctuations from season to season with successively lower peaks and troughs: a low of 33,000 tons in 1937-38 followed by a peak of 52,000 in 1940-41; a low of 23,000 tons in 1942-43, a peak of 40,000 in 1944-45; lows of about 18,500 tons in both 1947-48 and 1948-49; a slight rise to 24,600 tons in 1949-50 and finally a drop to 15,900 in 1950-51, the worst season since the depression years of 1930-32.

In the period between the depression and World War II, 1934-35 through 1941-42, the catch never fell below 30,000 tons. Since 1941-42, the catch has exceeded 30,000 tons in only two seasons and has fallen below 20,000 tons in three—this despite the development of the scoop fishery in the late thirties. Demand has been greater than supply over most of the seasons since the depression. There have been times when temporary gluts in the market cut the take, and since the war the scoop fleet has felt the reluctance of many canners to handle their catch. However, mackerel are becoming so scarce that the scoop fishermen in recent seasons have been hard put to catch enough for profitable fishing, and can not supply the canners willing to accept their fares. Economic pressure has consequently forced many of these small boats to desert a once lucrative fishery.

WITHIN-SEASON TRENDS, 1928-29–1950-51

As noted earlier, mackerel appear to be most abundant off Southern California in the fall. They become progressively scarcer during the winter and by the end of March are virtually unavailable. April has always been the month of poorest catches. In the early years of the cannery fishery, the season opened in May, but in the past decade there has been little activity until July, August or September. The disappearance of the spring fishery appears to be largely associated with a lack of fish, though price disputes and availability of tuna are contributory factors. Concern over the drop in total catch from 1935 to 1938 led to the canning industry voluntarily closing the season in the months of April and May from 1938 through 1941 and in June as well in 1940 and 1941. The April closure meant little, but in view of past experience, the May and June closures affected once lucrative months.

The early portion of the season, including the months of May through August, was of considerable importance during the period 1928-29–1938-39 inclusive. In these 11 years, landings comprised 24 to 47 percent of each season's catch, and in 1929-30 this was the most productive portion of the season. The decline in May and June catches, which started in 1936, coupled with the voluntary closed seasons from 1938 through 1941, brought about a drastic drop in early season landings. From 1939 through 1946, the contribution to each season's catch ranged from 1 to 10 percent, and total landings were less than those of the late season (January-April) except in 1938-39, and far below those of mid-season (September-December). Early season landings rose between 1946-47 and 1949-50 and from 1947-48 through 1950-51 exceeded those of the late season, contributing 13 to 33 percent of each season's catch. Purse

seine fishing in July and August accounts for the rise in relative importance. Over the 23-season period, 22 percent of the entire catch was landed during the early season.

The months of September-December, comprising the midseason, are by far the most productive. From the 1928-29 season through 1950-51, 456,502 tons, or 67.6 percent of all landings, were delivered during this period. From 1928-29 through 1939-40, from 42 to 67 percent of each

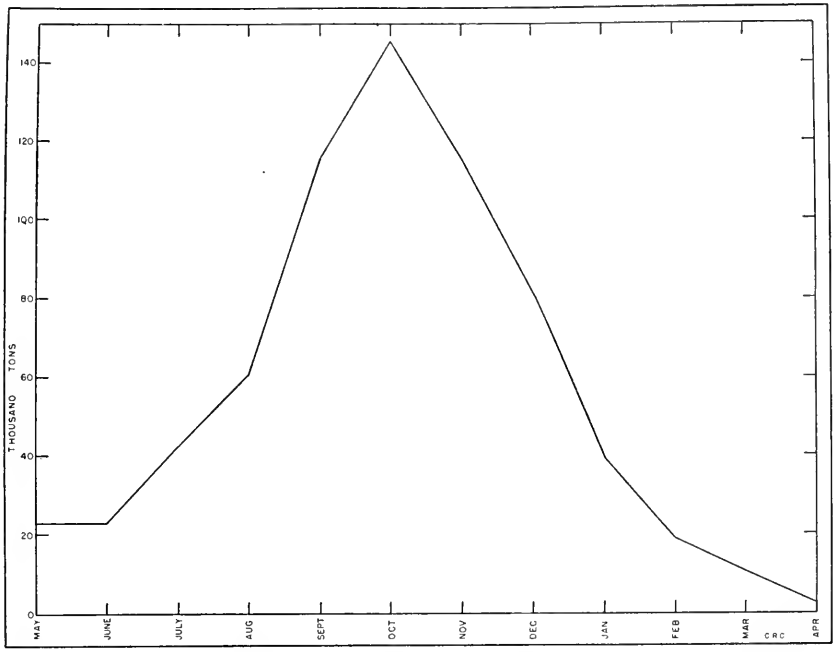

FIGURE 2. Total monthly landings of Pacific mackerel in the Los Angeles region during the 23 seasons, 1928-29–1950-51

season's catch was taken in midseason. The midseason proportion rose abruptly to 80 percent in 1940-41, varied from 76-90 percent from 1941-42 through 1948-49, then dropped to 65 and 68 percent in the next two seasons. Several factors account for the dominance of this four-month period. First, mackerel are unquestionably most abundant on the fishing grounds at this time. Second, the sardine season opened on November 1st until 1941 and on October 1st thereafter. Consequently, there are far more seiners on the grounds at this time and while few of them are seeking mackerel primarily, any will take them when sardines are not available. Third, the scoop fleet generally starts operations in early September, partly because the earlier months are recognized as poor mackerel months, but more because these boats are engaged in the potentially more lucrative albacore fishery or in the sport fishery during the summer. The drop in relative importance of the midseason in recent seasons reflects the rise in summer purse seining.

The late season is characterized in most years by poor mackerel fishing. Lack of fish, not a voluntary cessation of fishing effort, is responsible, for the purse seine fleet is active through January, and for many years the sardine season continued through March. Further, the scoop fleet will operate as long as fish can be found in profitable quantity. In 1940 particularly and to a lesser degree in 1941 and 1942, fish apparently remained in fair abundance on the fishing grounds until March. In 1939-40, the late season catch exceeded the early for the first time and continued to do so through 1946-47, this reflecting after 1941-42 the almost complete lack of a spring and summer fishery rather than success in the late season. Percentagewise, the late season reached its peak in 1931-32 and 1937-38 with 21 percent of the catch; of the 23-season total, 10 percent was landed from January through March.

In summary, the months of October, September, November and December in that order have been the most productive over the 23-season period, accounting for 67.6 percent of the entire catch. August, July and January follow, accounting for about 21 percent of the total. May and June, once good fishing months, have been of little consequence since the late thirties. February and March have rarely had significant catches and April never.

With the disappearance of the early season fishery in 1940, the midseason, always the leading period, became of paramount importance and remained so through most of the forties. In the last two seasons, the midseason has been of lesser relative importance because of the summer purse seine fishery. Further, total September landings since the war have exceeded those of October, and November has become a poor third.

THE FISHERY 1939-40–1950-51

Introduction

Catches by gear for each season are summarized in Table 3. "Seine" as used therein and in the following pages includes all landings by roundhaul boats. The vast bulk of the seine catch is made by purse seiners; the contribution of smaller vessels using bait nets is extremely small. The seiner fleet is readily identified and it is considered most unlikely that the "other and unknown" category includes any seine-caught fish. The scoop fleet, however, is far larger and more plastic; the operators can and do fish several types of gear. Only known scoop catches are included in the scoop category, but some scoop-caught fish are undoubtedly included in "other and unknown." The total tonnage in this classification is so trifling however, that errors are inconsequential. The scoop catch must not be considered as taken entirely with scoops, for most of the boats carry striker poles, and in the first season or two, a good proportion of the catch was taken by this method. Striker fishing is still employed at times when efforts to scoop have failed.

The relative importance of the scoop landings has decreased in recent years (Figure 3) though they remain dominant. In the first six seasons (1939-40—1944-45), 64.5 percent of all landings were scoop-caught and 33.9 percent, seine. The scoop catch exceeded the seine each season.

TABLE 3

Pacific Mackerel Landings in Tons by Gear—Los Angeles Region, 1939-40–1950-51

	Season											
	1939-40	1940-41	1941-42	1942-43	1943-44	1944-45	1945-46	1946-47	1947-48	1948-49	1949-50	1950-51
Seine	18,510	22,205	12,012	4,283	12,946	8,205	6,851	13,292	10,062	4,539	10,322	8,925
Scoop	27,339	29,477	21,187	17,820	22,213	30,614	17,942	14,626	8,484	13,759	14,147	6,918
Other and unknown	178	180	381	737	1,011	1,199	772	414	107	114	141	77
Totals	46,027	51,862	33,580	22,840	36,170	40,018	25,565	28,332	18,653	18,412	24,610	15,920

	Totals			Percentages		
	1939-40—1944-45	1945-46—1950-51	12 Seasons	1939-40—1944-45	1945-46—1950-51	12 Seasons
Seine	78,161	53,991	132,152	33.9	41.1	36.5
Scoop	148,650	75,876	224,526	64.5	57.7	62.0
Other and unknown	3,686	1,625	5,311	1.6	1.2	1.5
Totals	230,497	131,492	361,989	100.0	100.0	100.0

In the last six seasons, the proportion of the scoop catch decreased to 57.7 percent while the seine increased to 41.1 percent, and seiner landings were greater than scoop in 1947-48 and in 1950-51.

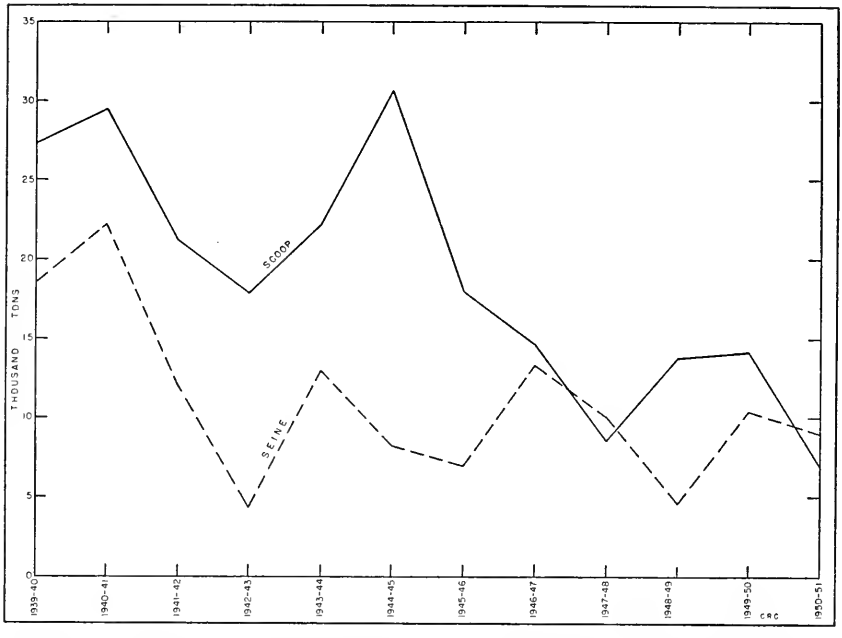

FIGURE 3. Catch of Pacific mackerel by gear in the Los Angeles region, 1939-40–1950-51. Other fishing methods contributed negligible amounts to the total landings (see Table 3).

The Seine Fishery

Seine catches by month and season are presented in Table 4. The 1939-40 and 1940-41 seasons were by far the best (18,510 and 22,205 tons). There were wide fluctuations without any marked trend in the 10 seasons following, with the low catch 4,283 tons in 1942-43 and the high 13,292 tons in 1946-47. Wartime restrictions on fishing and the fact that many of the newer and larger vessels had been diverted to the armed forces undoubtedly depressed the 1942-43 catch by an unknown but surely significant amount. Fishing in the second worst season (1948-49; 4,539 tons) was sharply curtailed by strikes in September, October and November. The scoop fleet operated during these months and enjoyed good fishing.

Nearly 20 percent of the 12-season catch was landed in the early season, largely because of the revived summer fishery of the last few seasons. Seiner activities in May and June have been almost nil. The early season was the least productive period until 1947-48, when it surpassed the late season; in 1948-49 and 1949-50 it was the most productive period, and in 1950-51 but slightly poorer than midseason.

TABLE 4

Landings in Tons of Seine-Caught Pacific Mackerel—Los Angeles Region, 1939-40–1950-51

	Season							
	1939-40	1940-41	1941-42	1942-43	1943-44	1944-45	1945-46	1946-47
May	12	39	5	0	0	20	33	130
June	397	37	0	38	5	19	0	57
July	797	143	1,263	3	18	63	0	33
August	2,574	1,053	694	0	1,317	91	323	115
Early season	3,780	1,272	1,962	41	1,340	193	356	335
September	3,092	2,377	3,206	66	2,400	3,096	1,576	4,520
October	364	10,241	1,762	428	1,316	2,466	2,547	513
November	3,066	3,521	2,292	1,998	4,990	1,052	576	1,590
December	561	1,236	472	964	1,078	676	537	3,384
Midseason	7,083	17,375	7,732	3,456	9,784	7,290	5,236	10,007
January	3,622	655	741	462	1,415	432	938	1,164
February	2,843	2,774	292	264	407	244	211	1,132
March	1,182	95	1,278	60	0	0	96	579
April	0	34	7	0	0	46	14	75
Late season	7,647	3,558	2,318	786	1,822	722	1,259	2,950
Season totals	18,510	22,205	12,012	4,283	12,946	8,205	6,851	13,292

TABLE 4—Continued

Landings in Tons of Seine-Caught Pacific Mackerel—Los Angeles Region, 1939-40–1950-51

	Seasons				Totals			Percentages		
	1947-48	1948-49	1949-50	1950-51	1939-40—1944-45	1945-46—1950-51	12 Seasons	1939-40—1944-45	1945-46—1950-51	12 Seasons
May	85	117	35	321	76	721	797	0.1	1.3	0.6
June	137	5	570	258	496	1,027	1,523	0.6	1.9	1.2
July	588	1,049	2,512	1,897	2,287	6,079	8,366	2.9	11.3	6.3
August	1,415	2,436	3,894	1,252	5,729	9,435	15,164	7.3	17.5	11.5
Early season	2,225	3,607	7,011	3,728	8,588	17,262	25,850	10.9	32.0	19.6
September	1,798	355	2,233	3,036	14,237	13,518	27,755	18.2	25.0	21.0
October	970	83	588	224	16,577	4,925	21,502	21.2	9.1	16.3
November	4,015	57	73	732	16,919	7,043	23,962	21.6	13.0	18.1
December	398	161	5	252	4,987	4,737	9,724	6.4	8.8	7.4
Midseason	7,181	656	2,899	4,244	52,720	30,223	82,943	67.4	55.9	62.8
January	158	155	64	274	7,327	2,753	10,080	9.4	5.1	7.6
February	220	0	40	50	6,824	1,653	8,477	8.7	3.1	6.4
March	243	87	180	92	2,615	1,277	3,892	3.3	2.4	2.9
April	35	34	128	537	87	823	910	0.1	1.5	0.7
Late season	656	276	412	953	16,853	6,506	23,359	21.5	12.1	17.6
Season totals	10,062	4,539	10,322	8,925	78,161	53,991	132,152	99.8	100.0	100.0

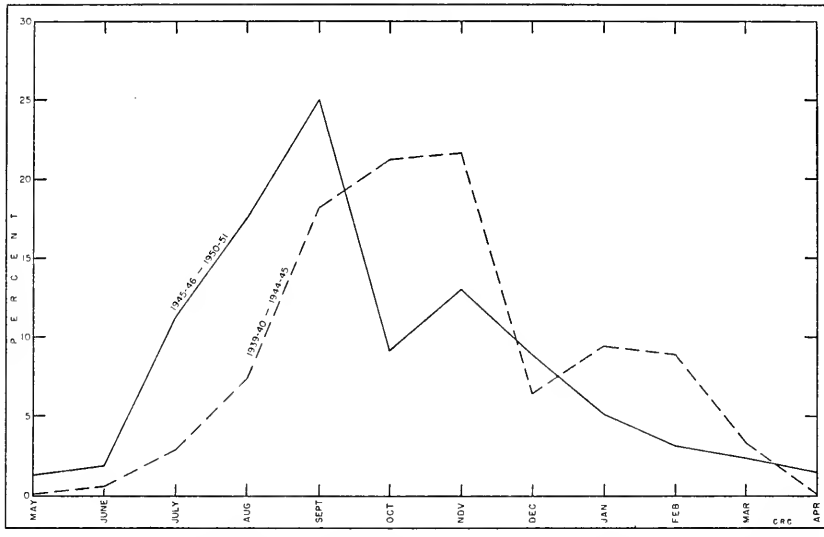

FIGURE 4. Monthly percentages of the total Los Angeles region seine catch for the six seasons, 1939-40–1944-45, compared with the monthly percentages for the six seasons, 1945-46–1950-51

While the midseason has been the most productive over the period involved (63 percent of the landings) December has not been good and there has been a consistant tendency for the season to reach its peak earlier. In recent seasons, September has averaged better than October or November, and July and August have increased in importance. In the last six seasons, August has been second to September, while July surpasses October and is but little behind November.

The most significant change in the seiner season lies in the increased importance of July, August and September in the later seasons and the corresponding drop in importance of October, November, and to a lesser degree January, February and March (Figure 4). Total November landings in the first six seasons (1939-40—1944-45) exceeded those of any other month. However, total September landings were best in the last six seasons (1945-46—1950-51).

The Scoop Fishery

Scoop catches by month and season are presented in Table 5. Seasonal catches have shown a pronounced decline since the peak season of 1944-45 (30,614 tons) and the catch in the best season of the succeeding six (1945-46) barely surpassed the worst (1942-43) of the first six (Figure 3). Fishing was poorest in 1950-51 when but 6,918 tons were delivered. World War II had less of an impact on the scoop fleet than on the seine. These vessels were not in demand by the armed forces and they were less hampered by wartime restrictions. Many of them unloaded at the ports of Santa Monica and Redondo Beach to avoid the much more stringent regulations in force at Los Angeles Harbor, and many others delivered, as they had in the past, at the canneries in Newport Beach. Fares delivered at Santa Monica and Redondo Beach were shipped by truck to the Los Angeles canneries.

TABLE 5

Landings in Tons of Scoop-Caught Pacific Mackerel—Los Angeles Region, 1939-40–1950-51

	Season								
	1939-40	1940-41	1941-42	1942-43	1943-44	1944-45	1945-46	1946-47	1947-48
May	6	2	20	0	0	3	0	2	21
June	126	13	8	7	5	0	0	0	19
July	462	124	60	4	1	1	0	0	21
August	294	970	516	6	46	644	139	4	103
Early season	888	1,109	604	17	52	648	139	6	164
September	684	2,032	2,739	1,197	2,549	7,875	1,893	902	3,664
October	4,653	6,276	8,595	5,583	6,494	8,843	4,730	3,652	3,880
November	6,566	10,101	5,378	6,501	7,427	6,320	6,243	3,557	488
December	7,919	5,439	2,142	2,813	3,788	5,330	4,649	5,178	158
Midseason	19,822	23,848	18,854	16,094	20,258	28,368	17,515	13,289	8,190
January	3,881	2,241	1,385	1,142	1,722	1,580	288	958	77
February	1,979	1,328	336	395	179	13	0	314	23
March	768	924	8	172	2	5	0	41	20
April	1	27	0	0	0	0	0	18	10
Late season	6,629	4,520	1,729	1,709	1,903	1,598	288	1,331	130
Season totals	27,339	29,477	21,187	17,820	22,213	30,614	17,942	14,626	8,484

TABLE 5—Continued

Landings in Tons of Scoop-Caught Pacific Mackerel—Los Angeles Region, 1939-40–1950-51

	Season			Totals			Percentages		
	1948-49	1949-50	1950-51	1939-40—1944-45	1945-46—1950-51	12 Seasons	1939-40—1944-45	1945-46—1950-51	12 Seasons
May	54	68	13	31	158	189	0	0.2	0.1
June	54	124	24	159	221	380	0.1	0.3	0.2
July	52	40	12	652	125	777	0.4	0.2	0.3
August	270	760	321	2,476	1,597	4,073	1.7	2.1	1.8
Early season	430	992	370	3,318	2,101	5,419	2.2	2.8	2.4
September	4,539	4,069	3,609	17,076	18,676	35,752	11.5	24.6	15.9
October	5,485	5,028	1,467	40,444	24,242	64,686	27.2	31.9	28.8
November	2,127	3,095	893	42,293	16,403	58,696	28.5	21.6	26.1
December	1,161	934	566	27,431	12,646	40,077	18.5	16.7	17.8
Midseason	13,312	13,126	6,535	127,244	71,967	199,211	85.7	94.8	88.6
January	5	17	5	11,951	1,350	13,301	8.0	1.8	5.9
February	0	6	0	4,230	343	4,573	2.8	0.5	2.0
March	0	4	0	1,879	65	1,944	1.3	0.1	.9
April	12	2	8	28	50	78	0	0.1	0
Late season	17	29	13	18,088	1,808	19,896	12.1	2.5	8.8
Season totals	13,759	14,147	6,918	148,650	75,876	224,526	100.0	100.1	99.8

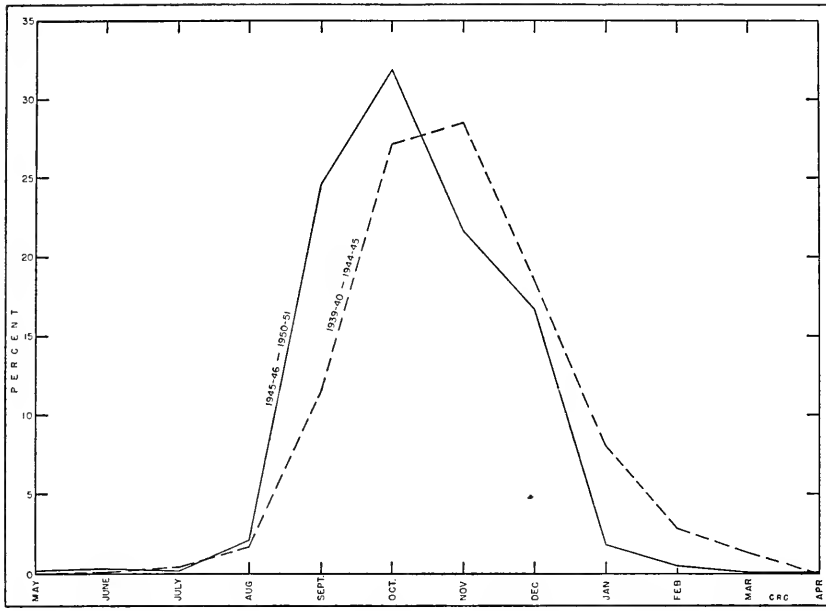

FIGURE 5. Monthly percentages of the total Los Angeles region scoop catch for the six seasons, 1939-40–1944-45, compared with the monthly percentages for the six seasons, 1944-45–1950-51

Despite the decline in the scoop fishery, seasonal landings have exceeded the seiner deliveries except in 1947-48 and 1950-51 and in both these seasons, the seiner margin was small. In all but one (1946-47) of the remaining 10 seasons, the scoop catch was substantially greater than the seine.

The early season is of no significance in the scoop fishery. Of the 224,526 tons of scoop-caught fish delivered in the 12 seasons, only 2.4 percent (5,419 tons) was taken during May-August and a large part of that in August. Most of the fleet which engages in scooping spends the spring and summer in the albacore and sport fisheries. The midseason is far and away the most important period, with nearly 89 percent of all landings. It is in September that the scoop fishery gets into full swing, while December usually marks its end. The late season was an important factor in the fishery only in 1939-40 and 1940-41, and in the last six seasons has contributed but 2.5 percent of all landings.

Within-season changes in the scoop fishery, though not as pronounced as for the seine, nonetheless follow a similar pattern (Figure 5) with the season reaching its peak earlier. A comparison of total monthly landings in the first six seasons with total monthly landings in the second six shows that September was better in the second period both in terms of tonnage and percentage contribution to the total catch. October, though with a smaller tonnage in the second period, made a larger contribution to the total catch in terms of percentage than it did in the first period. Each of the succeeding months November-March made a smaller contribution to the second period catch than to the first both in tons and percentage. November was the best month in the first period, followed by

October, December and September. In the second period, October was best, followed by September, November and December. The season reached its peak in December in 1939, November in 1940, 1942, 1943 and 1945, and in October in all the remaining seasons save 1950, when September was the best.

FISHING GROUNDS

Introduction

For a knowledge about fishing localities, the Department of Fish and Game is dependent largely on information supplied by the fisherman to the weighmaster at the time of unloading. The coastal waters of California are divided into numbered blocks, each encompassing 10 degrees of latitude and 10 degrees of longitude, and the fish receipt made out by the weighmaster contains a space in which to record the number of the block in which the catch was made. This system has been in effect since the early thirties, and now provides, on the average, reasonably accurate (judging from auxiliary information obtained through interviews with fishermen and field observations) and reasonably complete records. In presenting the data in this section, catches by individual blocks have been grouped into general fishing areas as shown in Figure 6. The Santa Monica, Newport and Santa Catalina areas comprise the "local" grounds, those remaining the "distant."

For many years, fishing has tended to concentrate along the mainland and within a few miles of the islands. Relatively few catches are made more than 10 miles from the nearest point of land. The most heavily exploited grounds now include the mainland coast from the vicinity of Port Hueneme to Oceanside, the east end of Santa Cruz Island and Anacapa Island, Santa Catalina Island, and San Clemente Island.

The Seasons Prior to 1939-40

In the early years of the fishery, the mackerel fleet operated close to port. Croker (1933) set the extreme limits of the Los Angeles fleet as "Anacapa Island in the west, San Clemente Island in the south, and Pt. San Juan [Dana Pt.] in the east" and the limits of the heavily fished area as Pt. Dume, Santa Catalina Island and Newport Beach. By 1936, the entire area now fished was exploited to some degree—the coast from Pt. Conception to San Diego and offshore to include all the islands.

Locality records for the first five seasons for which we have data are presented in Table 6. Almost all the information was obtained from fares delivered to canneries in the Los Angeles-Long Beach harbor area. Since virtually the entire Los Angeles cannery catch was made by lampara and purse seine boats during these seasons, the data reflect the activities of this fleet. Canning operations at Newport Beach commenced in 1935, and increased in volume over the last four seasons, with fishing operations conducted chiefly by the striker fleet and probably concentrated for the most part along the adjacent mainland. The relatively small tonnages delivered to fresh fish markets doubtless originated on the local grounds.

Block area records for 1934-35 are scant (1,605 out of 48,745 tons) but indicate a concentration along the mainland from Pt. Dume to Dana Pt., with some fishing at the west end of Santa Catalina Island and at the

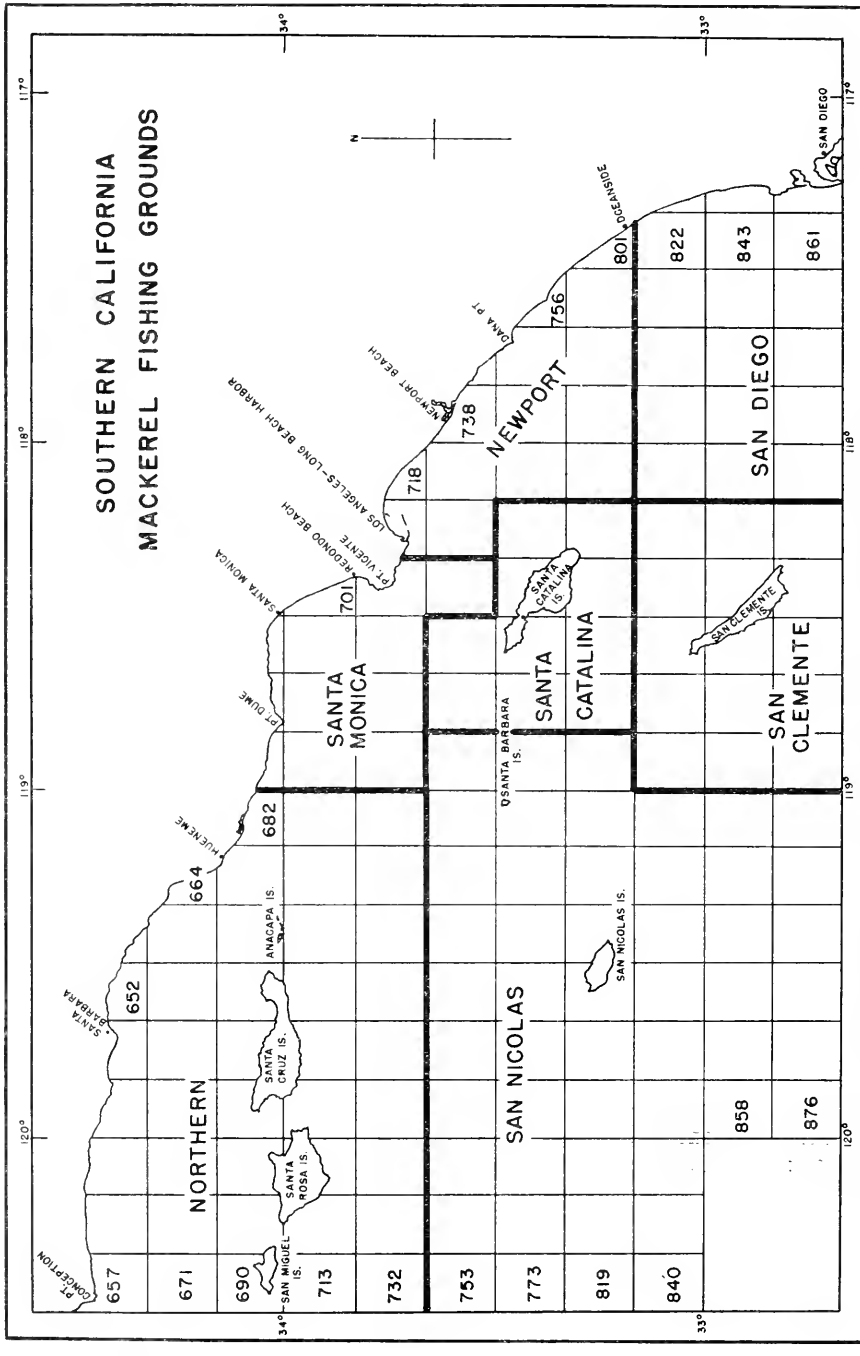

FIGURE 6. The coast of Southern California showing general fishing areas and numbered blocks

TABLE 6

Catches in Tons of Pacific Mackerel by Fishing Area—Los Angeles Region, 1934-35–1938-39
Locality Data Reflect Origins of Seine-Caught Fish Delivered at
Los Angeles-Long Beach Canneries Almost Without Exception

Fishing area	Season				
	1934-35	1935-36	1936-37	1937-38	1938-39
Santa Monica	451	8,911	3,692	1,979	969
Newport	1,068	5,347	5,048	1,860	4,041
Santa Catalina	21	433	282	3,489	1,029
Total, local	1,540	14,691	9,022	7,328	6,039
Northern	0	474	10,513	10,104	7,683
San Nicolas	0	0	610	1,602	2,119
San Clemente	64	186	1,084	1,524	6,126
San Diego	0	47	581	122	325
Total, distant	64	707	12,788	13,352	16,253
Total, known origin	1,604	15,398	21,810	20,680	22,292
Origin unknown	47,141	49,876	21,239	12,032	12,973
Seasonal totals	48,745	65,274	43,049	32,712	35,265
Newport Beach deliveries (Approximate)	0	2,500	2,600	4,400	7,200
Los Angeles-Long Beach Harbor cannery deliveries (Approximate)	47,400	62,100	40,000	28,000	27,800

north end of San Clemente Island. For the ensuing four seasons, 1935-36–1938-39, the records are better, although those for 1935-36 leave much to be desired. During these four seasons, there was a sharp decline in the contribution of the local grounds: from 95 percent in 1935-36 to 27 percent in 1938-39, with the Santa Monica area the most productive in 1935-36 and the northern area the leader in each of the following three seasons.

Seiner Grounds 1939-40–1950-51

Catches by general fishing area are presented in Table 7. Origins were given for nearly 93 percent of the 132,152 tons taken during the 12-season period. Local and distant grounds made nearly equal contributions to the 12-season catch (49 and 51 percent), and each led in six of the seasons.

There was little difference between the total catches of each of the three local areas: Santa Monica, 21,414 tons; Santa Catalina, 19,764 tons; and Newport 19,079 tons. Santa Catalina was the leading local area in six seasons (1939-40, 1944-45–1948-49), Newport in four (1942-43, 1943-44, 1949-50, 1950-51) and Santa Monica in but two (1940-41 and 1941-42). Santa Monica leads in total production largely because of the very high (6,938 tons) catch in 1940-41. Santa Catalina was the best single area in 1944-45, 1946-47 and 1948-49 and Newport in 1943-44 and 1949-50.

Seiner fishing in the Santa Monica area tends to concentrate at opposite ends of the area: the vicinities of Pt. Dume and Pt. Vicente. Santa

Monica Bay proper (Fish and Game District 19A) has been closed to seining since 1931. The entire coast of the Newport area is heavily fished with catches most numerous near Los Angeles Harbor and in the vicinity of Newport Beach and Dana Pt. At Santa Catalina Island, the east and west ends appear to be the favored grounds. Most of the waters within three miles of the island, comprising Fish and Game District 20, are closed to seining, though a small section (District 20A) on the south side adjacent to the west end is open.

TABLE 7

Catches in Tons of Seine-Caught Pacific Mackerel by Fishing Area
Los Angeles Region, 1939-40–1950-51 Seasons

Fishing area	Season						
	1939-40	1940-41	1941-42	1942-43	1943-44	1944-45	1945-46
Santa Monica	525	6,938	1,577	588	2,622	1,530	1,258
Newport	667	1,091	1,555	616	2,802	748	1,007
Santa Catalina	1,621	642	635	500	2,442	3,714	1,491
Total, local	2,813	8,671	3,767	1,704	7,866	5,992	3,756
Northern	7,250	8,526	6,127	1,830	2,312	1,030	2,182
San Nicolas	4,022	2,723	1,360	48	1,458	191	233
San Clemente	2,192	435	150	6	259	401	385
San Diego	284	551	76	103	180	0	55
Total, distant	13,748	12,235	7,713	1,987	4,209	1,622	2,855
Total, known origin	16,561	20,906	11,480	3,691	12,075	7,614	6,611
Origin unknown	1,949	1,299	532	592	871	591	240
Totals	18,510	22,205	12,012	4,283	12,946	8,205	6,851

Fishing area	Season					12 seasons	
	1946-47	1947-48	1948-49	1949-50	1950-51	Tons	Percentages
Santa Monica	2,200	1,701	968	865	642	21,414	17.5
Newport	2,046	1,198	1,044	4,521	1,784	19,079	15.6
Santa Catalina	3,891	2,567	1,314	186	761	19,764	16.1
Total, local	8,137	5,466	3,326	5,572	3,187	60,257	49.2
Northern	1,504	3,079	421	533	2,089	36,883	30.1
San Nicolas	219	60	18	261	987	11,580	9.4
San Clemente	1,333	467	465	2,654	1,984	10,731	8.8
San Diego	362	166	27	1,006	316	3,126	2.6
Total, distant	3,418	3,772	931	4,454	5,376	62,320	50.9
Total, known origin	11,555	9,238	4,257	10,026	8,563	122,577	100.1
Origin, unknown	1,737	824	282	296	362	9,575	0
Totals	13,292	10,062	4,539	10,322	8,925	132,152	0

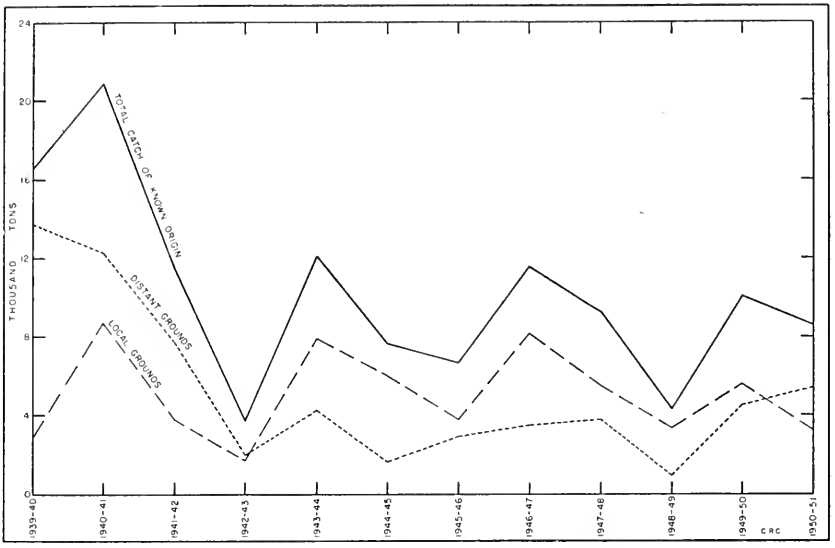

FIGURE 7. Contribution of the distant and local fishing grounds to the Los Angeles region seine catch, 1939-40–1950-51

Of the distant grounds, the northern is by far the most important. It has contributed 30 percent of the 12-season catch and was the most productive single area in seven seasons (1939-40–1942-43, 1945-46, 1947-48, and 1950-51) and the most productive of the distant areas in three of the remaining five. The San Nicolas and San Clemente catches each approximate 9 percent of the 12-season total; San Clemente surpassed the northern area in 1948-49 and 1949-50. San Diego is the least important, with 2.6 percent of the catches.

Anacapa Island is the focal point of the northern area fishery. Catches diminish westward along the adjacent islands of Santa Cruz and Santa Rosa, and the westernmost island, San Miguel, is, for all practical purposes, beyond the limit of the fishery. It is suspected that the occasional fares reported from San Miguel are taken mostly by boats en route south from Central California ports. Relatively little fishing is done along the mainland west of Port Hueneme. The San Nicolas area fishery is conducted near Santa Barbara and San Nicolas Islands. Catches are rarely reported from the open sea between Santa Cruz and San Nicolas, and less often from west or south of San Nicolas. Catches in the San Clemente area are made close to the island and in the San Diego area largely along the mainland.

Scoop Grounds 1939-40–1950-51

While virtually all seiner catches are delivered at Los Angeles-Long Beach Harbor, the scoop fleet operates not only out of this harbor but also out of Newport Beach. During the war years especially, many scoop boats fished out of Santa Monica Bay ports. Boats based at Los Angeles fish the three local areas, Santa Monica, Newport and Santa Catalina. Those from Newport Beach rarely go to Santa Monica, and those from Santa Monica Bay ports usually operated within the bay. Fish receipts which did not

show origin have been prorated in accordance with known origins by port by month for the period 1939-40–1948-49 in order to get a best estimate of the relative importance of each major fishing ground. For the last two seasons, unknowns have been prorated without regard to port; records have been much more complete since the war, the Santa Monica fishery has diminished greatly, and it was found that the simpler system gave results which were substantially the same.

Although the scoop fishery is regarded as confined to the three local areas, an occasional boat fishes south of Oceanside along the mainland in the San Diego area, and some catches are reported from beyond Santa Monica Bay in the northern area. Such catches have been credited to the Newport and Santa Monica areas respectively, as they represent modest extensions of the regular fishing grounds. In 1949-50, the records showed 58 tons of scoop-caught fish from San Clemente Island and this represented a definite movement into a new area. It was, as far as is known, not repeated in 1950-51.

The regular scoop grounds include Santa Monica Bay and the mainland coast south to the vicinity of Oceanside, and Santa Catalina Island. Fishing tends to concentrate within Santa Monica Bay, in the Newport

TABLE 8

Catches in Tons of Scoop-Caught Pacific Mackerel by Fishing Area
Los Angeles Region, 1939-40–1950-51 Seasons
Catches of Unknown Origin Have Insofar as Possible Been Prorated (See Text)

Fishing area	Season						
	1939-40	1940-41	1941-42	1942-43	1943-44	1944-45	1945-46
Santa Monica	8,939	9,859	11,425	8,461	12,137	19,817	10,511
Newport	2,293	11,663	7,157	4,710	7,958	10,439	6,144
Santa Catalina	6,400	7,943	2,579	4,640	2,066	358	1,287
Totals	17,632	29,465	21,161	17,811	22,161	30,614	17,942
Origin unknown	9,707 [1]	12	26	9	52	0	0
Totals	27,339	29,477	21,187	17,820	22,213	30,614	17,942

Fishing area	Season					12 seasons	
	1946-47	1947-48	1948-49	1949-50	1950-51	Tons	Percentages
Santa Monica	6,345	4,261	2,549	1,097	402	95,803	44.6
Newport	6,455	2,812	3,876	10,984	4,471	78,962	36.8
Santa Catalina	1,807	1,306	7,318	2,061 [2]	2,039	39,804	18.6
Totals	14,607	8,379	13,743	14,142	6,912	214,569	100.0
Origin unknown	19	105	16	5	6	9,957	
Totals	14,626	8,484	13,759	14,147	6,918	224,526	

[1] Consists chiefly of landings at Newport Beach. Most of the catches were made in the Newport area.
[2] Includes 58 tons reported from San Clemente Island.

Beach-Pt. Dume area, and along the mainland side of Santa Catalina from the center of the island to the east end. Scoop fishing is not affected by the closed areas which limit seining.

The estimated scoop catch by area is presented in Table 8. Santa Monica leads with nearly 45 percent of the 12-season catch, followed by Newport with 37 percent and Santa Catalina with over 18 percent. These figures tend to overestimate the importance of Santa Monica because of the large unknown tonnage in 1939-40 which unquestionably came from the Newport and Santa Catalina areas.

There is one striking feature in the season-to-season figures—the rise of Santa Monica to its peak of 19,817 tons in 1944-45 followed by its steady decline until in 1950-51 it produced but 402 tons. Santa Monica was the most important area from 1941-42 through 1947-48, but since then has been the poorest. The Santa Catalina area was the best in 1948-49 and Newport in the next two seasons. The drop in productivity of Santa Monica Bay alone accounts for the decrease in total scoop landings since 1944-45, with the slight rise in total landings in 1948-49 and 1949-50 attributable to better than average success at the island in 1948-49 and in the Newport area in 1949-50.

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1933. The California mackerel fishery. Calif. Div. Fish and Game, Fish Bull. 40, 149 p.

1938. Historical account of the Los Angeles mackerel fishery. Calif. Div. Fish and Game, Fish Bull. 52, 62 p.

NOTES

PINK SALMON IN PRAIRIE CREEK, CALIFORNIA

Another of those infrequent visits to California waters has been made by at least one individual of the species *Oncorhynchus gorbuscha,* the pink or "humpback" salmon. The specimen, a male 26 inches in fork length and weighing seven pounds, was taken in Prairie Creek, tributary to Redwood Creek in Humboldt County, on October 13, 1951. The normal spawning grounds for these fish lie well north of California, usually from Washington to Alaska. Pink salmon mature and spawn at the early age of two years and thus are the smallest of the Pacific salmons. Only the males develop the grotesque hump seen in the specimen pictured.

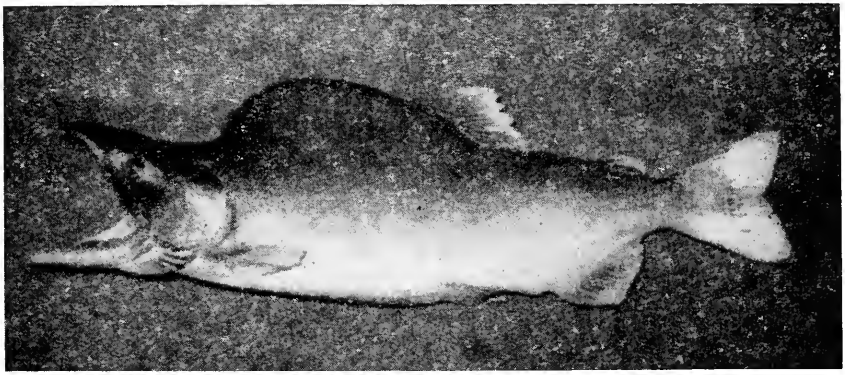

FIGURE 1. Pink salmon (*Oncorhynchus gorbuscha*) from Prairie Creek, California. *Photograph by J. B. Kimsey*

Previous appearances of the species in California waters have been recorded at various times; indeed, fairly respectable runs apparently occurred in some Mendocino County streams during 1937. (See "Pink Salmon in California" by A. C. Taft, California Fish and Game, vol. 24, no. 2, p. 197-8, April, 1938.) These, however, do not appear to have been repeated regularly and the appearance of isolated individuals in California remains noteworthy.—*S. C. Smedley, Bureau of Fish Conservation, California Department of Fish and Game, November, 1951.*

REVIEWS

The Oyster Industry of Willapa Bay, Washington

By Trevor Kincaid; The Tribune, Hwaco, Washington, 1951; 45 p. illustrated. $1.00. (for sale by California Co., Seattle)

"The Oyster Industry of Willapa Bay, Washington" is a fine nontechnical booklet covering the Japanese or Pacific oyster in one of the more important areas of its production in America.

The information presented is a good introduction to the methods of commercial oyster growers and will prove of worth to persons contemplating culturing oysters.

The greatest value of Professor Kincaid's booklet will be to enlighten the general public to the far reaching ramifications of the industry and the basic problems of planting, cultivating, and harvesting the valuable health-giving food, the oyster. The connoisseur of seafoods will find that getting the oysters to the table involves far more than the song and dance of the Walrus and Carpenter in "Alice in Wonderland."—*H. G. Orcutt, California Department of Fish and Game.*

Waterfowl and Their Food Plants in Washington

By Charles F. Yocom; University of Washington Press, Seattle, 1951; xvi + 272 p., illustrated. $5.00.

Here is a book of particular interest to those who wish to learn more about waterfowl along the Pacific Flyway. Yocom's main contribution is in presenting the status of the different species and their distribution as they occur in Washington. He includes observations made by himself and others for the Washington Department of Fish and Game as well as source material from earlier records on waterfowl in that state.

One feature of the book is the clear, concise manner in which it is written. Sixty-three illustrations readily transfer the reader to the problems or places reported.

Briefly, the chapters this reviewer considers best include those concerned with the status of individual species, the relative abundance of the wintering waterfowl, a survey on nesting and resident waterfowl, sex ratio counts, waterfowl and their relationship to hunting, food habits studies, and the important food and cover plants in Washington. This last chapter is well illustrated and contains 48 black and white plates of individual plant species with maps of their known areas of distribution.

Other topics which contribute little to present knowledge are hatching periods, brood studies, migration, management, and parasites and diseases.

Yocom recognizes the great need for further study on these birds, not only in Washington but along the entire Pacific Flyway. Though this book may not have general appeal to readers outside of Washington, it certainly can be recommended to anyone who seeks further knowledge of the waterfowl throughout the Pacific States.—*John B. Cowan, California Department of Fish and Game.*

The Clever Coyote

By Stanley P. Young and Hartley H. T. Jackson; The Stackpole Co., Harrisburg, Pa., 1951; xv + 411 p., 81 plates, 28 figs. $6.50.

This volume is in reality two books, printed as one, but markedly different in material and treatment.

Part One is an easily-read, entertaining collection of campfire tales and woods-lore telling of the coyote's distribution and general characteristics, and of methods of control. The yarns are spun in a true trapper style, complete with details concerning the exploits of an Amazon predator agent. It is quite evident the author has spent a number of years in the field, associating with trappers over the whole of North America. One thread prominently woven through the whole fabric is the fact that the coyote is a persistent and enjoyable part of our fauna, and must be controlled only when he takes advantage of the abundant food supply offered by concentrations of helpless domestic animals. Particularly fine is the chapter on the bounty system, which reflects the popular attitude of game technicians everywhere.

Part Two is strictly a scientific treatise of classification, which would have sold only in limited numbers by itself. While apparently very accurate and comprehensive, this section with its tendency to segregate a species into numerous subspecies will appeal mainly to taxonomists.—*Fred Ross, California Department of Fish and Game.*

The Fly and the Fish

By John Atherton; The Macmillan Company, New York, 1951; 195 p.; $5. Illustrated by the author in color and halftones.

Probably the greatest merit of this book lies in the fact that it is written by a man who not only deeply enjoys the contemplative art of angling, but also understands the high natural values associated with it. Here is one angler who doesn't pretend to be a self-instructed professional ichthyologist or an expert on the technical phases of fish conservation. The reader can quickly sense, however, that John Atherton is a true conservationist who likes fishing for its own sake rather than as a crutch for his ego.

It is especially interesting to read Mr. Atherton's book because he is an artist by profession and comprehends the art and techniques of representation. Through his eyes the reader is shown an extremely logical approach to the art of imitation by what is called the "impressionistic" theory. Briefly this is the application of natural patterns of broken color, as found in living things, to the design of artificial flies. The proof of the pudding is in the eating. Therefore, if we can believe the author, his flies will not only fill a long vacant space in the angler's fly case, but also prove quite consistent strike producers on difficult waters. The color plates of flies from his original paintings are very good. The highlight halftones are even better. Coupled with these is an ability to write which is reminiscent of Roderick Haig-Brown.

Both the novice and the veteran can learn from the how-to-do-it chapters, although the book is obviously for the experienced angler. Various chapter headings include "The Rise and 'Light Pattern,'" "Touching on Rods," "Lines and Leaders" and even "Ladies —and Guides." In addition, many standard and original flies are described, and there are diagrams showing how to tie them. To Californians it will be a pleasure to know that the author, although having resided in Vermont for many years, spent part of his early life on the West Coast. The chapter on steelhead fishing shows a fine sense of humor, and Mr. Atherton does not spare praise for the lordly sea-run rainbow.

Among the many recent books on flies, fly tying and fly fishing, this small volume rates at the top for its thoughtful observations, its fine writing and its beauty.—*Herbert E. Pintler, California Department of Fish and Game.*

Outline of Upland Game Bird Management

By Elizabeth B. Beard and Warren W. Chase; The Overbeck Co., Ann Arbor, Michigan, 1951; iv + 143 p., $3 (paper).

This manual is the fourth in a series of teaching aids in wildlife management authored by Elizabeth Beard and Warren Chase of the University of Michigan. The others are outlines of the principles of wildlife management, waterfowl management, and management of fur animals.

The most important features of the manual are the list of references and the rather comprehensive outlines of the history and distribution, physical characteristics, life history, and management practices for each species treated. The outlines are partially informative and partially just a listing of points upon which information should be obtained from the literature. Our native grouse and quail, wild turkey, woodcock, band-tailed pigeon, mourning and white-winged doves, and the introduced chukar and Hungarian partridges and ring-necked pheasant are covered.

These manuals are primarily workbooks for students and teachers of wildlife management. Workers in the field will find the bibliographic sections very handy when reviewing the literature, and the outlines may be useful to some to refresh their minds as to the over-all picture when memory lags or when they "can't see the forest for the trees." While useful additions to the library, they are hardly volumes to furnish an evening of interesting reading.—*Chester M. Hart, California Department of Fish and Game.*

The Shell Book

By Julia Ellen Rogers; Charles T. Branford Co., Boston, 1951; xxi + 503 p., 87 black and white + 8 colored plates. $6.50.

Every year many old movies are re-released which would have been better left gathering dust on a shelf, basking in the glory earned during their original showing. This holds true for books as well. "The Shell Book' was originally published in 1908 and 480 pages of that original text have not been changed. Since 1908 scientists throughout the world have worked out many intricate details of the physiology, anatomy, growth, feeding habits and natural history of mollusks. None of this information has been encompassed in this revision. As a result much of the book is so out of date that it reads like a fairy tale.

The most recently accepted scientific names, however, are available as a list in the back of the book. Unfortunately incorrect names still adorn more than two-thirds of the species discussed in the text and are used in the illustrations. This volume in its present revised form is definitely not recommended.—*John E. Fitch, California Department of Fish and Game.*

REPORTS

FISH CASES

October, November, December, 1951

Offense	Number of arrests	Fines imposed	Jail sentences (days)
Abalone: Overlimit; undersize; out of shell; failure to show license	34	$855 00	
Angling: Closed season; no license; too near dam; 2 rods; setline; using another's license; fishing in closed area; failure to show license; possessing spear within 300 feet of river; nonresident using resident license; night fishing; predating license; using snag hooks; possessing illegal gaff; alien using citizen's license; false statement to secure license; angling too near fishway	172	2,683 00	50
Barracuda: Overlimit and selling fish taken on sport boat	1	25 00	
Bass: Undersize and overlimit black bass; seining black bass; undersize and overlimit striped bass; angling with 3 lines for striped bass; taking at night; striped bass set line; selling striped bass; possessing striped bass in bait store; using another's license; no license	73	3,250 00	
Carp: Taking with seine	1	100 00	
Catfish: Undersize; overlimit; set line	6	225 00	
Clams: Undersize and overlimit cockles; overlimit big neck clams; undersize and overlimit pismos; failure to show license; no license; digging before legal time; late digging; digging at night; failure to return undersized to hole; possessing out of shell	124	2,795 00	15
Commercial: Selling undersized catfish; taking crabs, closed season; overlimit rock bass; no commercial license; waste of fish (lobster tails); no license on boat; possessing undersized lobsters; set net; possession illegal trout; no boat log; lobster traps in closed season and closed area; illegal use purse net; selling undersized yellowtail; no party boat registration; failure to keep records; operating trawl net, Dist. 10; failure to post notice of bag limits on party boat; possessing sturgeon and striped bass on commercial boat; diving for abalone without permit; failure to deliver fish receipts to commission	90	4,960 00	9
Frog: Overlimit	1	25 00	
Crab: Closed season	1	25 00	
Lobster: Trapping in closed area; possessing in closed season	3	75 00	
Pollution: Oil; bluestone	7	600 00	
Rockfish: Using another's license; overlimit	1	20 00	
Salmon: Possessing gaff and taking at night; snagging; no license; possessing too near dam; spearing; taking on spawning beds; taking from closed area	47	1,730 00	
Sunfish: Overlimit; taking in closed waters	4	95 00	
Trout: Overlimit; 2 poles; no license; undersize; transporting illegal trout into state; spearing; night fishing; fishing in closed stream	31	969 50	
Sale of seized fish		2,131 50	
Totals	596	$20,564 50	74

GAME CASES

October, November, December, 1951

Offense	Number of arrests	Fines imposed	Jail sentences (days)
Antelope: Illegal transport and no license; no tags and no permit	2	$100 00	
Bear: Killing in closed season	2	100 00	
Deer: Taking spike buck, doe, fawn; forked horn in refuge; using 2-deer tag in 1-deer district; nonresident using resident license; failure to tag; no license; deer in refuge; possessing another's deer tags; overlimit; transferring deer tag; mutilating tag; transporting deer without validating; hunting at night; shooting from public road and within 150 yards of dwelling; possessing illegally taken deer; refusing to show game on demand; spotlighting; using illegal ammunition; illegal transport; failure to retain deer hide 10 days; removing sex evidence; using .22 rifle; hunting deer in both archery and regular season; taking spike buck during doe hunt; false statement to obtain tags and license; taking in closed season and with loaded gun in car	293	22,854 00	705
Deer Meat: Illegal transportation; possessing in closed season	11	1,250 00	210
Dove: Possessing closed season; overlimit; loaded gun in car; bringing in overlimit from Mexico; shooting from auto; unplugged gun; early shooting; no license; late shooting	119	3,215 00	
Duck: Late shooting; early shooting; overlimit; trespassing on shooting grounds; shooting from road; closed area; no license; closed season; shooting from powerboat; bringing overlimit from Mexico; night hunting; herding ducks on refuge; unplugged gun; rallying ducks with powerboat; nonresident using resident license; illegal transportation; taking without stamp; leaving cooperative area without checking out	291	10,972 00	25
Elk: Illegal transport	3	350 00	
Geese: Overlimit; hunting in closed area; no license; shooting in refuge; shooting from power boat; taking after hours; taking with rifle; early shooting	17	455 00	
Hunting: No license; loaded gun in car; making false statement to secure license; unplugged gun; early shooting; late shooting; hunting on cooperative area without permit; failure to show license; trespass; using another's license, transferring license voided by court; obtaining license under false name; gun in refuge; shooting from auto; shooting from powerboat; shooting from public highway; hunting off cooperative area with patches and permits; possessing another's deer tags; nonresident using resident license; shooting from highway bridge; defacing deer tags; using illegal ammunition; alien using citizen license	832	23,039 50	21
Mudhen: Shooting from powerboat; taking after hours; no license and unplugged gun; hunting on cooperative area without permit	6	185 00	
Nongame birds: Taking sparrow, robin, yellowhammer, meadowlark, grebe, western piper, seagull, sandhill crane, shorebirds, godwit, snipe; taking from powerboat	13	290 00	
Partridge: Taking chukar in closed season	2	230 00	
Pheasant: Failure to tag; possessing untagged birds and loaded gun; no license and no tags; hen pheasant; possessing unlawfully taken pheasant in cooperative area; trespass; closed season; overlimit; bringing pheasant taken in Mexico closed season; failure to declare; shooting from auto; removing evidence of sex; early shooting; late shooting; unplugged gun; hunting without patch; selling wild pheasant; loaded gun in car; possessing another's tags; using .22 rifle	203	8,666 00	152
Quail: Closed season; hunting at night using artificial light; early shooting; loaded gun in car; late shooting; possessing and transporting illegal quail; overlimit; unplugged gun; taking in refuge; no license	38	1,885 00	
Pigeon: Closed season; no license	2	60 00	
Rabbit: Closed season; no license; loaded gun in car; hunting at night; unplugged gun; using artificial light; overlimit; shooting from car	68	2,025 00	
Sagehen: Taking closed area; possessing in closed season	12	580 00	
Squirrel: Taking tree squirrels, gray squirrels	5	150 00	
Swan: Taking three swans; shooting whistling swan	7	525 00	
Totals	1,926	$76,932 00	1,113

SEIZURES OF FISH AND GAME

October, November, December, 1951

	Number	Pounds
Fish:		
Abalone	445	
Barracuda	20	
Bass	315	
Cabrilla		6,342
Carp		30
Catfish	147	13
Clams	5,598	
Crab	160	340
Frog	39	
Lobster	753	6,652
Rockfish	30	
Salmon	58	
Sturgeon	1	
Sunfish	111	
Trout	433	
Tuna	14	
Yellowtail		220
Game:		
Bear	1	
Deer	174	
Deer Meat		589
Dove	1,229	
Duck	839	
Elk	1	180
Geese	22	
Mudhen	15	
Nongame Birds	31	
Pheasant	232	
Partridge	3	
Pigeon	2	
Quail	116	
Rabbit	131	
Sagehen	4	
Squirrel	10	
Swan	8	

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